

THE ROLE OF ORNAMENTAL HORTICULTURE IN PLANT INVASION: A CASE STUDY IN ROMANIA

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Abstract

*Ornamental horticulture, a global practice, has significantly contributed to the proliferation of plant invasions on a worldwide scale. The European landscape, perpetually influenced by evolving horticultural trends, has witnessed the introduction of plants from diverse continents. The horticultural industry actively promotes ornamental species that exhibit characteristics traits conducive to their success, such as rapid growth, low maintenance requirements, resilience to local climatic conditions, and resistance to pests and pathogens. However, all these characteristics also ensure their success outside the gardens, so the number of alien plants escaping cultivation in native ecosystems increases from year to year. This study explores the evidence underscoring the fundamental importance of ornamental horticulture in introducing and promoting alien plant species, ultimately leading to their escape into natural ecosystems. In the context of Romania, a comprehensive analysis revealed that 264 ornamental taxa have escaped cultivation, and 30 of them have become invasive. Notably, six taxa, including *Ailanthus altissima*, *Asclepias syriaca*, *Humulus scandens*, *Impatiens glandulifera*, *Ludwigia peploides*, and *Myriophyllum aquaticum*, are of concern to the European Union, warranting special measures for population control and mitigation. This paper seeks to raise awareness about the urgent need for implementing international and European codes of conduct and codes of practice specifically addressing horticulture, ornamental plants, and the management of invasive alien species. The information provided highlights the crucial role of regulatory frameworks in mitigating the unintentional ecological impact of ornamental horticulture. It underscores the importance of collaborative efforts to preserve biodiversity and uphold ecological balance.*

Key words: alien, non-native, decorative plants, floriculture, phytodiversity.

INTRODUCTION

Plants with ornamental value have been cultivated and commercialized since ancient times. The Egyptians, Greeks and Romans were known to be plant lovers and cultivators of many ornamental plants (Huxley, 1978). Thus, over time, plant lovers and professional plant hunters from all over the globe have permanently introduced plants with ornamental characteristics into their personal collections, some even brought from faraway continents (Van Kleunen et al., 2018). But, these passion for collecting plants paved the way for more structured interventions; in particular, the horticultural industry has amplified this trend through the deliberate and mass introduction of a very large number of non-native ornamental species. These species have been selected for

their cultivation in a wide range of landscapes from public and private gardens, to cemeteries, botanical gardens and dendrological parks (Bell et al., 2003, Dehnen-Schmutz & Touza, 2008; Drew et al., 2010; Humair et al., 2015; Mayer et al., 2017). However, certain introduced plants have crossed the borders of the gardens and successfully adapted to the wild landscape where they have begun to reproduce freely and uncontrolled. Through their uncontrolled spread, some species have become invasive, negatively affecting local biodiversity (Pysek et al., 2012).

It is found that ornamental horticulture has had a considerable impact on the introduction and spread of invasive plant species globally (Drew et al., 2010; Humair et al., 2015; Hulme et al., 2018; Bayón & Vilà, 2019). Specifically, in Europe, an estimated 80% of current alien plant

species were originally introduced as ornamentals or for agriculture (Hulme, 2007). This trend has been amplified in recent decades by technological advances and marketing strategies that have revolutionized the way the horticultural industry produces and distributes ornamental plants. In this context, many of these plants are traded and distributed without proper assessment of their invasive potential, thus contributing to the growing problem of invasive species threatening native biodiversity (Drew et al., 2010).

The selection of plants for ornamental purposes is not a random process. Horticultural marketing strategies emphasize promoting plants with a visually appealing appearance to customers, but these kinds of plants often possess characteristics that predispose them to becoming invasive. These characteristics include large flowers, decorative fruits and seeds, an extended flowering period or the ability to flower several times a year, minimal care requirements, resistance to heat or drought conditions, high adaptability and increased stability in time (Anderson et al., 2006; Mack, 2005; Pyšek et al., 2007; Van Kleunen et al., 2010; Van Kleunen et al., 2018). In addition, special attention is paid to the ease of propagation, the shortening of the early ripening period and the resistance to the stress associated with transport, as well as to a low sensitivity to harmful insects or pathogens (Drew et al., 2010; Hulme, 2011).

E-commerce is the latest and most accessible method for introducing ornamental plants, offering the possibility to order plants from different corners of the globe (Kowarik, 2005; Dehnen-Schmutz et al., 2010; Humair et al., 2015). More than fifty years after the advent of the Internet, it has evolved into the most convenient way to purchase products (Lenda et al., 2014). For these reasons, online trade is recognized as a major factor in promoting the introduction of invasive alien species and constitutes a significant biosecurity risk, especially by circumventing border controls and strict regulations on the plant trade (Ricciardi et al., 2007).

Even though some countries have implemented legal restrictions to limit e-commerce of invasive or potentially invasive alien plant species, online sales are increasing (Kikillus et

al., 2012; Dehnen-Schmutz & Touza, 2008). Sellers find ways to get around the legislation by using outdated or popular names for invasive species to avoid detection and restrictions (Lenda et al., 2014).

Given the difficulty and high costs associated with the eradication of invasive species, it is essential to prioritize the prevention of the introduction, naturalization and invasion of new ornamental species. This approach is justified by a much more advantageous cost-benefit ratio, both from an ecological and economic perspective (Vanderhoeven et al., 2011).

Romania is particularly susceptible to invasions by alien plant species, largely due to its central geographical position in Europe and intensive trade with other countries (Anastasiu & Negrean, 2007; Sârbu et al., 2022). The first reports of invasive plant species in Romania date back to the beginning of the eighteenth century (Anastasiu et al., 2005; Dumitraşcu et al., 2010). However, systematic studies on alien ornamental plants commenced 18 years ago when Anastasiu et al. (2005) published the initial list of alien ornamental plants identified as escaped, naturalized, or invasive.

Years after this initial compilation, the situation in Romania evolved with additional ornamental plants being reported either in botanical gardens (Nagodă et al., 2014; Szatmari & Caprar, 2015; Negrean et al., 2017) or within urban spaces and private gardens (Sârbu, 2007; Anastasiu et al., 2011; Anastasiu et al., 2017). The most recent list of alien ornamental plants in Romania (Urziceanu et al., 2020) counts 264 alien species and subspecies of ornamental interest, including 199 occasional, 37 naturalized, and 28 invasive species. This signifies a nearly threefold increase in reported taxa over 15 years, accounting for approximately a quarter of the naturalized ornamental alien species in Europe (Pyšek et al., 2009; Urziceanu et al., 2020).

Starting from the recognition of the role that ornamental horticulture has on the introduction and spread of invasive alien plant species, as well as the urgent need to develop effective strategies for their prevention and management, our study aims to deepen the understanding of this complex phenomenon. In this context, the purpose of our study is to conduct a screening and analyse the presence of ornamental

invasive plants in the online horticultural market.

MATERIALS AND METHODS

We used the updated lists of alien plant species in Romania, provided by the POIM project, as a starting point for the identification of ornamental species with invasive status (Anastasiu et al., 2019). A database containing synonyms, common name, ornamental properties, type of propagation, year of introduction, the life form was done.

To assess the presence of these species on the Romanian market, we studied internet offers from importers to producers, nurseries, wholesale suppliers, garden centers, DIY stores and individual offers. Google searches were conducted using relevant keywords as well as the scientific names, synonyms and common names of the plants. We experienced challenges with taxonomy and spelling, with some sites showing outdated and out-of-date names. We also identified cases where two different species were marketed under the same name. Google searches were conducted using keywords such as "garden plants", "ornamental plants", "honey plants", "nurseries", "forestry units (forest detours)", "plant shops", "ornamental perennial plants", "offer decorative plants", as well as the scientific names, synonyms and popular names of the plants.

We also found cases where two different species were marketed under a generic name, such as *Humulus* sp., *Reynoutria* sp., *Rudbeckia* sp., *Solidago* sp.

RESULTS AND DISCUSSIONS

Within the context of Romania's recognized list of 130 invasive and potentially invasive species (Anastasiu et al., 2019), we identified 30 invasive plant taxa that have been introduced for ornamental purposes within the national territory, as detailed in Table 1. These taxa comprise a mix of life forms, including 11 woody plants and a variety of herbaceous plants (5 annuals, 2 biennials, and 10 perennials). Such diversity indicates a wide array of establishment and spread strategies, underscoring the complexity of managing these species (Hodkinson and Thompson, 1997).

These plants were introduced both for their ornamental value (flowers, leaves, overall foliage texture, fruit and aesthetic form) but in the same time for their high adaptability to environmental conditions and the ease of propagation.

Most of them were introduced between 1800 and 1900, 7 species being reported in the last 100 years (*Humulus scandens*, *Impatiens glandulifera*, *Oenothera glazioviana*, *Prunus serotina*, *Reynoutria japonica*, *Symphotrichum lanceolatum*, *Myriophyllum aquaticum*) and only two in the last 20 years (*Reynoutria* × *bohemica* - 2004, *Ludwigia peploides* - 2020). This situation indicates that the invasiveness is determined by a long residence time, the propagules bank increasing over time and also the probability of spreading, establishment, and the founding of new populations (Rambuda & Johnson, 2004; Rejmánek et al., 2005; van Kleunen & Johnson, 2007). On the other hand, the fact that some species quite recently introduced became invasive very quickly can be explained by the fact that they were already adapted to local conditions when were introduced (Pyšek et al., 2009). It should also be mentioned that the last two species were automatically included on the list of invasive species in Romania, being present on the list of Union Concern species in Europe.

During our study, we examined 59 websites that sell ornamental plants to ascertain the market availability of invasive plant species. Regrettably, our study revealed that 57 of these (96.61%) included in their offers at least one invasive ornamental species. Many recognized invasive species are still offered daily on the internet to most countries in the world (Humair et al., 2015). This situation is not peculiar to Romania, the high number of websites that offer these types of plants may indicate that the problem of invasive plants is very little known in Romania or is known but ignored (Humair et al., 2015). This disregard is not necessarily determined for reasons of financial gain, although research has shown that horticulturists prefer exotic (non-native) species that attract customers having as a reason that native species do not have the features required by customers. The same study shows that horticulturists' familiarity with a non-native species and sometimes invasive might lead to a

cognitive conflict with the expert definition of the non-native origin of a species: a species that is characterized as 'foreign' by experts is 'familiar' to horticulturalists due to their daily work and they cannot perceive it as a plant that can have negative effects on the environment (Humair et al., 2014).

Also, another aspect is the deficit in the legislation regarding the management of alien invasive species. Although the accession to the Convention on Biological Diversity and the European Convention through Law no. 13/1993 imposes measures against invasive alien species, Ministerial Order no. 979/2009, the most direct regulation, has limited legal force. Emergency Ordinance no. 57/2007 recognizes the need to limit the introduction of alien invasive species, but does not provide the necessary tools for effective implementation. Weak control of trade in non-native species allows their import and trade in the absence of specific restrictions or prohibitions in other relevant sectors. On the contrary, in some situations the maintenance or introduction of these species is encouraged. For this reason, activities to prevent, control and eradicate invasive alien species do not benefit from legislative support in any activity sector (Bara et al., 2023).

Our analysis show the lack of information that the traders make available to the buyers taking regarding the invasive capacity of the sold species. Only a single website of the 59, provided additional information regarding the invasiveness of the species it sells. This highlights a significant gap in the disclosure of important information to consumers which could allow them to make informed decisions.

Among the 30 invasive ornamental plant taxa we investigated, 20 species could be bought in Romania's ornamental plant online market. The other 10 species (*Echinocystis lobata*, *Impatiens glandulifera*, *Oenothera glazioviana*, *Reynoutria × bohemica*, *Reynoutria japonica*, *Solidago canadensis*, *Sicyos angulatus*, *Symphyotrichum × salignum*, *Symphyotrichum lanceolatum*, *Ludwigia peploides*) are not currently for sale and gardeners usually got these through swapping propagules with each other.

For the 20 species present in Romanian trade, living plants (14 species), rare seeds (6 species)

and vegetative organs (*Helianthus tuberosus* - tubers, *Rudbeckia laciniata* - rhizomes) were offered. Only two species were identified both offers as live plants and seeds (*Lycium barbarum*, *Humulus scandens*).

The rich offer of living plants as seedlings or saplings, with increased chances of survival, although these species have both types of reproduction can be an advantageous marketing strategy for both, producers and consumers. Thus, living plants, cost more than few seeds, but at the same time the consumer should invest the time and resources necessary to obtain quality plants like the ones offered by the horticultural industry.

The species most frequently listed in online catalogs are *Acer negundo* and *Lycium barbarum*. *Acer negundo* is particularly prevalent and has been widely planted in urban areas across much of Europe for centuries due to its horticultural and landscape appeal, including its rapid initial growth (CABI, 2024). Currently, 'Fleming' variety, known for its variegated leaves, is very popular on the market. Although cultivars with variegated leaves appear to be less invasive, but those who own such plants must be aware of the wild rootstock on which they are grafted (Mędrzycki, 2011).

Lycium barbarum, first introduced as a decorative plant, has become nowadays very popular for its goji berries, which many people call 'Superfoods'. It's a tough plant that can handle pollution, drought, and cold weather well. It reproduces easily germinative by seeds and also vegetatively through suckers, creating dense bushes (Sirbu & Oprea, 2011).

The online trade alarmingly lists five species that have raised concerns within the European Union: *Ailanthus altissima*, *Asclepias syriaca*, *Humulus scandens*, *Impatiens glandulifera*, and *Myriophyllum aquaticum*.

Ailanthus altissima was available in 4 offers as living plants. It was particularly surprising to find that the nursery of the Suceava Forestry Directorate, an entity comprised of forestry specialists, had listed *Ailanthus altissima* along with 3 other invasive species for sale as live plants *Lycium barbarum*, *Parthenocissus inserta*, and *Elaeagnus angustifolia*. This oversight underscored a critical achievement: there is a pressing need for enhanced

collaboration across different fields to ensure mutual understanding and address shared concerns regarding invasive species. This experience has highlighted the importance of interdisciplinary efforts in managing and preventing the spread of invasive species effectively. The first record of *Ailanthus altissima* in Romania dates back to 1866 in Transylvania, with further documentation in 1898 near Bucharest. Presently, it is considered among the most aggressive invasive species in Europe, encroaching upon disturbed habitats as well as dry grasslands, forest edges, and riverbanks in Romania. Its widespread planting in urban areas owes to its resilience to drought and air pollution. The species proliferates rapidly both through seeds and vegetatively via suckers, often starting with a few isolated individuals that excessively multiply.

Asclepias syriaca was found in the offers of 3 online stores as a living plant being present on the market, especially as a honey plant. Thus, against the backdrop of the pollinator crisis, the plant is grown for beekeeping by private garden owners as well as by small honey producers (Tokarska-Guzik & Pisarczyk, 2015). This species was initially mentioned in Moldova in 1836 and later in Transylvania in 1866. Previously cultivated mainly in private and botanical gardens as an ornamental plant, it is now prevalent in various habitats, including roadsides, river floodplains, meadows, orchards, and even within agricultural fields (Sîrbu & Oprea, 2011). The plant produces seeds that spread by wind to considerable distances and reaching different types of habitats (Csontos et al., 2009). As a clonal plant, it presents a large capacity for vegetative reproduction, with the help of buds on the rhizome and adventitious roots (Follak et al., 2021)

Humulus scandens was found in 2 online offers, only using the synonym name, *Humulus japonicus*. Being an annual species, both offerings were represented by seeds. The exact date of introduction in Romania of this plant is unknown, but its first mention as a spontaneous plant was made by Morariu in 1942. It is distinguished from *Humulus lupulus* by its 5-7 lobed leaves, longer petioles than the leaf blade, and smaller female flowers. This invasive climbing species invades flood plains,

stream banks, roadsides, old fields, forest edges and waste areas where it can suffocate both herbaceous and woody plants (Georgescu et al., 2021).

Impatiens glandulifera was not found in any offerings on the market. This plant, known for its showy and scented flowers, was introduced to Romanian gardens as early as 1882 (Sîrbu & Oprea, 2011). It is classified as one of the 100 worst alien species in Europe (DAISIE, 2009). It became naturalized and invasive in riparian and disturbed habitats. A single plant can produce (500) 800-1700 (2500) seeds (Hodgson et al., 2020). The seeds are explosively discharged from the capsule when ripe and also are dispersed by water when plants grow along streams and rivers (Helsen et al., 2021). The effects of this species' invasion are significant, studies suggesting that this species can alter ecosystem functioning and services such as erosion control, pollination and nutrient cycling (Martinez-Cillero et al., 2019).

Myriophyllum aquaticum was identified in 8 offers as a living plant. Among these, only one was a plant shop, with the rest being aquaristics websites, where the plant is mainly sold as an aquarium species. In Romania, this species has been cultivated since 1947 in the thermal waters of the thermal lake Pețea in Bihor County (the western part of Romania), currently without water (Sîrbu et al., 2021). Another location has not been mentioned since the date of introduction, its presence on the national list being due to the presence on the list of invasive alien species of Union Concern according to the Regulation (EU) No. 1143/2014 of the European Parliament and of the Council. However, the climate changes in recent years and its presence in Romanian trade increase the chances that the plant will establish itself in our conditions.

CONCLUSIONS

The high number of invasive plant species on the Romanian trade shows the need to implement management and control strategies to mitigate the impact of invasive ornamental plants. These must target educational campaigns for public awareness and also for as well as those involved in the horticultural industry, clear labelling of invasive plants,

limiting sales of invasive plants and encouraging the use of native species (Peters et al., 2006; Burt et al., 2007; Gagliardi & Brand, 2007; Coats et al., 2011; Vanderhoeven et al., 2011; Yue et al., 2011; Humair et al., 2014). Also, implementing a complex monitoring system that includes all actors in the horticulture industry is also an effective approach to minimizing the introduction of invasive plant species (Humair et al., 2015). Furthermore, various voluntary codes of conduct have been proposed (Heywood and Brunel, 2009; Brundu et al., 2011; Verbrugge et al., 2014) to promote responsible practice among retailers, users and consumers. In addition, it is essential that they are complemented by predictive tools capable of determining which species have the potential to acclimate and spread under current climate conditions, considering the impact of climate change. A relevant example is the Plant Risk Evaluation (PRE) tool for ornamental plants, developed in North America (Conser et al., 2015) what it can provides a promising basis for testing its applicability in Romania as well. The plant species that evaluated and accepted should be included in an national whitelist list

and marked at points of sale with a "green" label, indicating a reduced likelihood of becoming invasive. On the other hand, species that are rejected and already spread outside the cultivation area should be given a "red" label, signaling a high risk of invasiveness, to allow consumers to make informed choices, according to the study by Hulme and collaborators in 2018.

Alarmingly, the online market features five species identified as concerning by the European Union, suggesting a disconnect between regulatory oversight and marketplace practices. The non-application of European legislation is reflected in the Romanian legislative gaps. However, in December 2022, Romania took a step forward by approving the National Action Plan to combat the introduction of invasive alien species, marking an improved commitment to managing these challenges (Bara et al., 2023).

All these measures will not materialize and will not be successful if improving of communication and collaboration among various experts and stakeholders in the field of ornamental plant management and characteristics won't happen.

Table 1. List of the 30 invasive plant taxa that have been introduced for ornamental purposes (Abbreviation: G - generatively, V - vegetatively)

No.	Taxon	Family	Common name (in romanian)	Ornamental features	Type of propagation	First report in Romania	Life form
1.	<i>Acer negundo</i> L.	Sapindaceae	Artar american	leaves, aesthetic form	G, V	1856	Ph
2.	<i>Ailanthus altissima</i> (Mill.) Swingle	Simaroubaceae	Cenușer, Falsul otetar	leaves, flowers, fruits, aesthetic form	G, V	1866	Ph
3.	<i>Amaranthus hypochondriacus</i> L. (syn: <i>Amaranthus hybridus</i> (Vell.)	Amaranthaceae	Moșul curcântului, Amaranth roșu	leaves, flowers, aesthetic form	G	1866	T
4.	<i>Amorpha fruticosa</i> L.	Fabaceae	Amorfa arbustivă, Salcâm pitic	flowers	G, V	1856	Ph
5.	<i>Asclepias syriaca</i> L.	Apocynaceae	Ceara albinei	flowers, fruits	G, V	1836	H
6.	<i>Bassia scoparia</i> (L.) A.J.Scott [syn: <i>Kochia scoparia</i> (L.) Schrad.]	Chenopodiaceae	Cipru de grădină	leaves, aesthetic form	G	1816	T
7.	<i>Echinocystis lobata</i> Torr. & A. Gray	Cucurbitaceae	Bostânaș spinos	fruits, aesthetic form	G	1904	T
8.	<i>Elaeagnus angustifolia</i> L.	Elaeagnaceae	Sălcoara mirositoare	leaves, flowers, aesthetic form	G, V	1792	Ph
9.	<i>Fraxinus pennsylvanica</i> Marshall	Oleaceae	Frasinul de Pennsylvania	leaves	G	1910	Ph
10.	<i>Hellianthus tuberosus</i> L.	Asteraceae	Topinambur, Nap porcesc	flowers	V	1778	H
11.	<i>Humulus scandens</i> (Lour.) Merr. (<i>Humulus japonicus</i> Siebold & Zucc.)	Cannabaceae	Hamei japonez	aesthetic form	G	1937	T
12.	<i>Impatiens glandulifera</i> Royle	Balsaminaceae	Balsamina, Sliabănog	flowers	G	1925	T
13.	<i>Juniperus virginiana</i> L.	Cupressaceae	lenupăr de Virginia	leaves, aesthetic form	G	1856	Ph
14.	<i>Lycium barbarum</i> L.	Solanaceae	Cătină de garduri, Goji	flowers, fruits	G	1842	Ph
15.	<i>Morus alba</i> L.	Moraceae	Dud decorativ	leaves, aesthetic form	G	<1600	Ph
16.	<i>Oenothera biennis</i> L.	Onagraceae	Lumina nopții, Lumânăriță	flowers	G	1816	Th
17.	<i>Oenothera glazioviana</i> Micheli	Onagraceae	Primula de seară	flowers	G	1957	Th
18.	<i>Parthenocissus inserta</i> (A. Kermer) Fritsch	Vitaceae	Viță-de-vie ornamentală	leaves, fruits, aesthetic form	G, V	1898	Ph, Li
19.	<i>Prunus serotina</i> Ehrh.	Rosaceae	Cireș negru	flowers, fruits, aesthetic form	G	1967	Ph
20.	<i>Reynoutria × bohemica</i> [Chrtek & Chrteková] (Fallopia × bohemica) [Chrtek & Chrteková] J.P.Bailey	Polygonaceae	Troscoț gigant	stem, leaves	G, V	2004	H
21.	<i>Reynoutria japonica</i> Houtt. [Fallopia japonica (Houtt.) Ronse Deert.]	Polygonaceae	Iulișcă, troscoț japonez	stem, leaves	G, V	1952	G-H
22.	<i>Robinia pseudacacia</i> L.	Fabaceae	Salcâm	flowers	G, V	1750	Ph
23.	<i>Rudbeckia laciniata</i> L.	Asteraceae	Mărită-mă-mamă	flowers	G, V	1855	H
24.	<i>Sicyos angulatus</i> L.	Cucurbitaceae	Castravetele stea	fruits, aesthetic form	G	1816	T
25.	<i>Solidago canadensis</i> L.	Asteraceae	Sânziană de grădină	flowers	G, V	1866	H
26.	<i>Solidago gigantea</i> Aiton	Asteraceae	Vergea de aur gigant	flowers	G, V	1886	H
27.	<i>Symphoricarum × salignum</i> (Willd.) G.L.Nesom (<i>Aster × salignus</i> Willd.)	Asteraceae	Stelute, Aster	flowers	G, V	1866	H
28.	<i>Symphoricarum lanceolatum</i> (Willd.) G.L.Nesom (<i>Aster lanceolatus</i> Willd.)	Asteraceae	Stelute, Aster	flowers	G, V	1940	H
29.	<i>Myriophyllum aquaticum</i> (Vell.) Verde.	Haloragaceae	Pene de papagal	aesthetic form	V	1947	HH
30.	<i>Ludwigia peploides</i> (Kunth) P.H. Raven	Onagraceae	Primulă de apă	flowers	G, V	2020	HH

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