

First escaped populations report of two ornamental and cultivated plants in Iran

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Abstract

Based on the present field surveys, two ornamental and cultivated species with high invasion potential have escaped in certain areas of northern and southern Iran. The four o'clock flower (*Mirabilis jalapa*) and castor bean (*Ricinus communis*) have been observed to have escaped from their cultivation ranges and have consequently undergone a change in invasion status, becoming naturalized. They are extensively cultivated and naturalized in urban areas across numerous regions of Iran. The IUCN Environmental Impact Classification of Alien Taxa (EICAT-IUCN) and the Socio-Economic Impact Classification of Alien Taxa (SEICAT) were employed to evaluate the potential risks these species may pose to native flora and fauna, as well as to human well-being. It was determined that, the castor bean and four o'clock flower have the potential to cause significant and moderate impacts on native species through competitive mechanisms. In the SEICAT approach, human health and safety were identified as constituents of human well-being. As a result, the most frequent occurring mechanisms leading to environmental impacts were competition, transmission of disease and poisoning/toxicity. These results suggest that, these species may be more competitive than the native ones in the urban vegetation. It is imperative to gain a deeper understanding of their actual impact on native taxa to bridge the gap in data and ensure accurate management decisions. Therefore, it is recommended that, conservation strategies be devoted to control the spread of these species in urban ecosystems.

Keywords: *Euphorbiaceae*, Hyrcanian forest, invasive status, naturalized, *Nyctaginaceae*

نخستین گزارش گریز دو گونه گیاه زینتی و کاشته شده در ایران

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خلاصه

ورود برخی گیاهان به محیط‌های جدید به دلیل توانایی آن‌ها در گذر از موانع زیستی و غیرزنده می‌تواند منجر به مهاجم شدن آن‌ها شود. ورود گیاهان مهاجم به عنوان یکی از مهم‌ترین تهدیدها برای تنوع‌زیستی است، به طوری که در کشورهای در حال توسعه، به عنوان یک چالش بزرگ برای کشاورزی و رفاه انسان تلقی می‌شود. براساس بررسی‌های میدانی حاضر، دو گونه زینتی و کشت‌شده با پتانسیل مهاجم بالا در برخی مناطق شمالی و جنوبی ایران به عرصه‌های طبیعی ورود کرده‌اند. گونه‌های لاله‌عباسی (*Mirabilis jalapa* L.) و کرچک (*Ricinus communis* L.) از محدوده کشت خود گریخته و در نتیجه به وضعیت مهاجم تغییر کرده‌اند. آن‌ها به طور گسترده در بسیاری از مناطق شهری ایران کشت و پرورش داده می‌شوند. در این تحقیق، طبقه‌بندی تأثیرات زیست‌محیطی IUCN گونه‌های بیگانه (EICAT-IUCN) و طبقه‌بندی تأثیر اجتماعی-اقتصادی گونه‌های بیگانه (SEICAT) برای ارزیابی خطرات احتمالی این گونه‌ها برای گیاهان و جانوران بومی و همچنین برای سلامت انسان به کار گرفته شد. خروجی سیستم ارزیابی EICAT نشان داد که کرچک و لاله‌عباسی از طریق مکانیسم رقابت، پتانسیل ایجاد اثر منفی بر گونه‌های بومی دارند. در رویکرد SEICAT، سلامت و ایمنی به عنوان اجزای تشکیل‌دهنده رفاه انسان شناسایی شد. بیشترین مکانیسم‌هایی که منجر به اثرات زیست‌محیطی می‌شود رقابت، انتقال بیماری و مسمومیت/اسمیت بود. این نتایج نشان داد که این گونه‌ها ممکن است رقابتی‌تر از گونه‌های بومی در پوشش گیاهی شهری باشند. برای رفع این شکاف در داده‌ها و اطمینان از تصمیمات مدیریتی دقیق، درک عمیق‌تر از تأثیر واقعی آن‌ها بر گونه‌های بومی ضروری است. بنابراین، توصیه می‌شود که راهکارهای حفاظتی برای کنترل پراکندگی این گونه‌ها در اکوسیستم‌های شهری اختصاص داده شود.

واژه‌های کلیدی: جایگاه مهاجمی، جنگل‌های هیرکانی، فرفیونیان، گل‌کاغذیان، گونه‌های مهاجم

Introduction

The introduction of alien plants has been linked to a notable decline in biodiversity among native species and their conservation status, disruption of community structure, impeded vegetation growth, significant alteration of soil bioprocesses, and economic costs (Pimentel *et al.* 2005, Ricciardi 2007, Vilà *et al.* 2011). The introduction of these alien plants to a different region is the result of human activities, whether accidental or deliberate (Pyšek & Richardson 2010). Despite an increase in studies examining the adverse impacts of alien plants, the implemented restrictions proved inadequate in limiting the spread of new introductions (IPBES 2019). A significant proportion of the weedy and invasive alien flora in Iran is introduced via imported propagules, primarily for ornamental purposes (Pahlevani & Sajedi 2011). Some of these exotic species consume the largest share of water and nutrient resources in rural and urban areas, particularly in drylands. This trend is gradually changing the face of native flora in each region (Ghahremaninejad *et al.* 2021). Of the more than 300 alien plants documented in Iran, the majority are concentrated in the Hyrcanian province, situated in the northern Alborz Mountains (Pahlevani & Tahmasebi 2021, Sohrabi *et al.* 2023a). The Hyrcanian forests represent significant areas of the Tertiary relict floras of the Old World within the Irano-Turanian floristic region. The Hyrcanian floristic province, which extends along the southwestern and southern shores of the Caspian Sea from the Talish in the Republic of Azerbaijan to three provinces in northern Iran (Gilan, Mazandaran and Golestan Provinces), is notable for its high number of endemic species (Boulos *et al.* 1994, Ghorbanalizadeh & Akhane 2022, Pahlevani & Frajman 2023). The number of alien species in the Hyrcanian region is increasing as a result of various disturbances, particularly the introduction and cultivation of new ornamental plants in the luxury green spaces of the region's newly constructed villas and mansions, which are situated in proximity to forested areas and coastal regions. This is coupled with the region's lack of freezing temperatures during winter season and high resource availability. For the aforementioned reasons, the majority of problematic neophytes are released and escaped from urban landscapes and recreational parks, where they are introduced. On the other hand, the majority of released and escaped alien species are found in ruderal habitats, particularly along roadsides and forest margins. As a consequence of the expansion and development of urbanization and mansion growth in the mountainous forests and plains of the aforementioned provinces, has resulted in an increase in the presence of nonnative plants. This phenomenon has been observed in some parts of Mazandaran and Gilan Provinces. This trend is considered a significant threat to the native flora, particularly the endemic and endangered species of Hyrcanian forests. The first checklist of alien plants of Iran includes 311 species, of which 131, 167, and 13 species were classified as casual, naturalized and invasive, respectively (Sohrabi *et al.* 2023b). It is therefore crucial to enhance our comprehension of the current status of alien plants and to develop the capacity to accurately identify both current and potential invasive species, with a particular focus on naturalized plants and their habitats (Pyšek *et al.* 2004).

A recent survey revealed that, certain alien plants have altered their invasion status, effectively evading control and establishing themselves in natural areas. The four o'clock flower or marvel of peru (*Mirabilis jalapa* L.), is one of the most commonly cultivated ornamental species belonging to the *Nyctaginaceae* family which has been introduced and cultivated for a considerable length of time in urban areas across Iran. The four o'clock flower is a perennial herb, although in temperate regions it is cultivated as an annual herb. It has been introduced from Central America as an ornamental plant since the 1500s, subsequently becoming naturalized on other continents (POWO 2024). This species has been identified as a weed and an invasive species in several countries across Asia, Africa, South America and Oceania (Vélez-Gavilán 2016). It propagates via seeds and has robust tuberous roots that enable it to persist during periods of drought (Xu *et al.* 2008, Li & Xu 2022). As a weed, it causes significant ecological harm in a variety of habitats, including

agricultural fields, gardens, roadsides, forest edges, and pastures. Its high reproductive capacity and allelopathic potential allow it to outcompete native species, posing a significant threat to biodiversity in invaded ecosystems (Xu *et al.* 2008).

The castor bean (*Ricinus communis* L.) is a perennial herb of the *Euphorbiaceae* family that originated in the Horn of Africa and is cultivated as an oil and ornamental plant in numerous countries worldwide (POWO 2024). This plant is an important oilseed crop with great utilitarian value in industry, pharmaceutical, and agricultural sectors. Its oil is unique among vegetable oils because it is the only commercial source of a hydroxylated fatty acid (Salihu *et al.* 2014). However, it has been documented as an escaped noxious weed and invasive species in many introduced countries, occupying a vast range of habitats (Henderson 2001, Langeland *et al.* 2008, Goyal *et al.* 2014, Silva & Fabricante 2022). The high seed production and ease of expansion by seed and fruit dispersal methods (autochory, myrmecochory and ectozoochory) collectively contribute to the accelerated establishment of this alien species. Consequently, the probability of the species being introduced and invaded new habitats are high (Dandeno 1904, Santo 2007, Martins *et al.* 2009).

In light of the species' high invasion potential, it is impressive to gain a more comprehensive understanding of its current distribution and the environmental and socio-economic impact it has, in order to make informed management decisions. This paper aims to categorize two escaped species, *M. jalapa* and *R. communis*, based on their environmental and socio-economic impact, utilizing the EICAT-IUCN classification and SEICAT methodology. Additionally, we have mapped the current escaped population of these species in Iran, and have discussed potential management options.

Materials and Methods

The potential environmental impacts of the species were evaluated in accordance with the EICAT-IUCN guidelines for each of the 12 mechanisms of impact (Volery *et al.* 2020, Kumschick *et al.* 2024). The severity of the impact was scored on a scale ranging from minimal concern (MC), minor (MN), moderate (MO), major (MR) to massive (MV) (Kumschick *et al.* 2024).

The socio-economic impacts of two alien plants were evaluated based on the SEICAT methodology proposed by Bacher *et al.* (2018), which allows the classification of species on a scale of five levels, ranging from minimal to massive impact. A distinctive aspect of the SEICAT approach is its reliance on changes in human activities as a unifying metric for gauging impacts on well-being (Probert *et al.* 2023).

The data regarding the species environmental and socio-economic impacts were obtained from a review of the literatures on the potential impacts of the species at the global level. Relevant data for environmental and socio-economic impacts was found in 32 articles/reports/online databases for 10 impacts involving two species. The category with the highest score, indicating the most severe impact, was used. To quantify uncertainty about the correct classification, confidence ratings of 'high,' 'medium' or 'low' were assigned to each assessment (Hawkins *et al.* 2015).

In this study, field studies of contaminated areas were conducted, and the geographic location of affected areas was recorded (Table 1). Subsequently, a map of the contaminated areas was prepared using the Mapview package in the R environment (Ver. 2.11.2).

Results and Discussion

Of the 12 existing environmental impact mechanisms, five were identified for the studied species, including competition, poisoning/toxicity, transmission of disease, chemical impact on ecosystem, and structural impact on ecosystem. The highest scores were assigned to MO and MR for the four o'clock flower and castor bean, respectively. The confidence rate for the highest-scoring mechanism was classified as medium (Table 2).

The competitive ability, allelopathic property, and toxicity of *M. jalapa* coupled with seed dispersal methods are apparently advantages for overcoming to the native plants. The competition ability of *M. jalapa* over native plants related to its root storage provides an advantage for competition, especially in drought conditions (Xu *et al.* 2008). The alteration of mitosis and aberrations of the chromosomes that causes the reduction of native plants growth were attributed to its allelopathic and toxic potential (Zhou *et al.* 2008). Many viruses were isolated from this species and have potential to be mentioned as alternative host for viruses like Tomato chlorotic spot virus, Chili leaf curl, mottle virus and Parietaria mottle virus (Brunt & Kitajima 1973, Parrella 2002, Hatlestad *et al.* 2011, Wang *et al.* 2012, Duarte *et al.* 2016). The phenotypic and morphological plasticity, alteration of the microbial community structure in the soil, and allelopathic potential of the castor bean represent significant advantages against native plants (Martins *et al.* 2011, Mominul Islam & Kato-Noguchi 2013, Hereira-Pacheco *et al.* 2021).

The results of this study, based on the SEICAT methodology and literature reviews, indicate that, the impact intensity has a negative impact on human health and safety. The species in question were classified as MO and MR for the four o'clock flower and castor bean, respectively (Table 2); and they have been identified for having the potential to cause poisoning. The allergenic pollen produced by the castor bean has a significant impact on human health. Castor bean pollen has been identified as an allergen that has been linked to respiratory symptoms, particularly affecting the nasal passages (García-González *et al.* 1999). There have been reports of severe anaphylactic reactions to castor bean, which were confirmed by immunoglobulin E (IgE) testing (Navarro-Rouimi & Charpin 1999, Koshanfar 2004, Coattrevec *et al.* 2017). The importance of a comprehensive medical history in the field of allergology highlights the potential for castor bean to induce life-threatening anaphylaxis (Coattrevec *et al.* 2017).

The toxic components of the four o'clock flower, such as tannins, alkaloids, flavonoids, phenolic compounds, terpenes, and saponins are present in the roots and seeds. Ingestion of these plant parts has been demonstrated to affect the digestive tract and may result in abortions in women (Monday 1988). In India, this species has been identified as an invasive plant (Mushtaq *et al.* 2019), with occurrence in Bengaigaon and Kamrup classified as environmental weeds (India Biodiversity Portal). The use of castor bean meal, press cake, or other byproducts of castor oil production as a protein source for feed or fertilizer is limited by the toxicity of the seeds, primarily due to the highly toxic protein ricin and the less toxic alkaloid ricinine (Hajoun *et al.* 2023). All parts of the plant are toxic, particularly the seeds (Wedin *et al.* 1986).

Table 1. Escaped populations of two alien species of four o'clock flower and castor bean in Iran

Taxon	Locality	Coordination	Date	Data collector	Habitat
<i>Mirabilis jalapa</i>	Golestan Prov.: Gorgan, Gorgan River	N 36.817458 E 54.452626	Oct. 2024	Sohrabi	Riverside
<i>M. jalapa</i>	Golestan Prov.: Kordkuy	N 36.800611 E 54.109935	Jul. 2024	Sohrabi	Urban landscape
<i>M. jalapa</i>	Golestan Prov.: Kordkuy to Bandar-e Gaz, Livan-e Sharghi	N 36.736881 E 53.883759	Jul. 2024	Sohrabi	Roadside
<i>M. jalapa</i>	Mazandaran Prov.: Amol, near to Amol	N 36.205863 E 52.385190	Sept. 2024	Sohrabi	Roadside
<i>Ricinus communis</i>	Mazandaran Prov.: Sari to	N 36.356420 E 53.188050	Aug. 2024	Sohrabi	Roadside & forest margin

	Kiasar, on roadsides				
<i>R. communis</i>	Mazandaran Prov.: Sari, near Khazar square	N 36.583502 E 53.061557	Sept. 2024	Sohrabi	Urban landscape & highway side
<i>R. communis</i>	Golestan Prov.: Gorgan, Gorgan River	N 36.841561 E 54.407626	Oct. 2024	Sohrabi	Urban landscape & riverside
<i>R. communis</i>	Bushehr Prov.: Dalaki, Faryab waterfall	N 28.898189 E 51.469316	Mar. 2009	Pahlevani	Around waterfall & date grove
<i>R. communis</i>	Baluchestan Prov.: Sarbaz	N 26.633803 E 61.257534	Mar. 1949	Mirsalavatian	Riverside
<i>R. communis</i>	Hormozgan Prov.: ca. 40 km NW Gavbandi	N 27.319925 E 52.852821	Mar. 2009	Pahlevani	Urban landscape

The field studies in the present investigation, have identified the four o'clock flower and castor bean as naturalized plants with the potential to become invasive in areas where they have escaped cultivation. The four o'clock flower was observed primarily on roadsides in Golestan and Mazandaran Provinces, and it is likely that it was introduced to these areas via urban waste (Fig. 1). The seeds of this plant exhibit a high germination capacity, germinating in early spring when the weather is suitable (Li & Xu 2022). The growth period of the plant in aforementioned provinces will exceed seven months. A prolonged growing period increases the probability of higher seed production and invasive potential. This plant has been observed to escape cultivation and is now growing on the banks of the Gorgan River (Fig. 2). It is possible that seeds may spread to a longer distance by water. This plant has been included on the list of invasive species in Japan since 1982, and there are restrictions in place regarding its cultivation (Satake *et al.* 1982). It is imperative that, a restriction be placed on the cultivation of this species in the northern region of Iran.

The castor bean was observed in significant density on disturbed areas, including urban areas, roadsides, riverbanks, field margins, areas near waterfalls, as well as near the date groves in several cities across Mazandaran, Golestan, Bushehr, Hormozgan and Baluchestan Provinces. Due to the lack of frost and the high population of this species in Iran, there is a significant risk of it becoming invasive in the north and south of the country, particularly in light of global climate change. The castor bean has been identified as a potential invasive species in the Galveston Bay area (<https://galvbayinvasives.org/>). This species can be observed as a very large shrub and evergreen plant in the north and south of Iran (Fig. 3).

Table 2. Socio-economic and environmental impact classification of two alien plants of four o'clock flower and castor bean

Taxon	SEICAT	Confidence	EICAT	Confidence
<i>Mirabilis jalapa</i>	MO	Medium	MO	Medium
<i>Ricinus communis</i>	MR	Low	MR	Medium

SEICAT: Socio-economic impact classification of alien taxa, EICAT: Environmental impact classification for alien taxa, MR: Major, MO: Moderate.



Fig. 1. Escaped points distribution of *Mirabilis jalapa* & *Ricinus communis* in Iran.

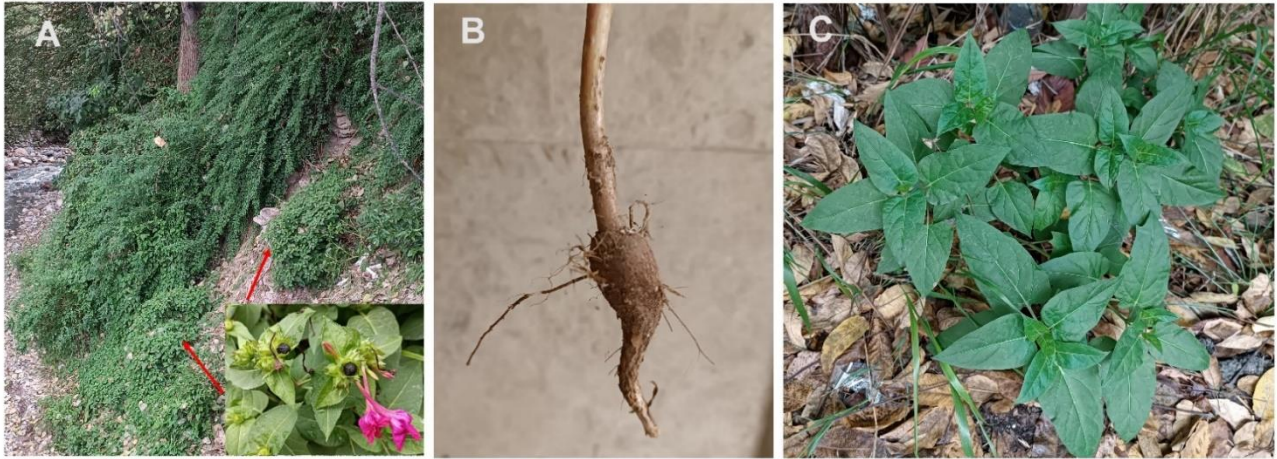


Fig. 2. The growth of the *Mirabilis jalapa* in Gorgan riverbanks: A. Invaded habitat with flowering and fruiting shoots, B. Tuberous root, C. Seedlings & young plants (Photo by S. Sohrabi).



Fig. 3. The escaped castor bean (*Ricinus communis*) in Gorgan riverbanks (A & B: Photo by S. Sohrabi) and Faryab waterfall (C: Photo by A.H. Pahlevani).

It is imperative to update the list of alien plants and monitor their invasive status in order to make informed management decisions (Sohrabi *et al.* 2023a). Furthermore, it is of paramount importance to consider the quarantine and prevention of the introduction of alien plants, particularly those with high potential for invasiveness. This is especially relevant in the northern and southern provinces, which experience frost-free periods and are therefore particularly vulnerable to invasions. In the initial checklist of alien plants in Iran, the invasive status of these two species was classified as casual (Sohrabi *et al.* 2023b). However, recent investigations have demonstrated that, the four o'clock flower and castor bean have naturalized and are progressing towards becoming invasive, absent the implementation of effective management strategies.

Recent observations have highlighted the unregulated cultivation of alien plants and the pivotal role of garden waste as a primary source for the escape of ornamental and medicinal plants into natural habitats. While certain measures have been implemented (e.g., regional guidelines on plant importation), comprehensive policies to regulate the cultivation and disposal of such plants remain limited. Evidently, more stringent regulations and targeted actions are required in order to address these gaps in an effective manner. The risk of invasion of these species can be mitigated through the implementation of management strategies and dissemination of information to the local population. In addition to threatening biodiversity, alien and invasive species can have a significant economic impact on agricultural systems and community health (Pahlevani & Sajedi 2011, Sohrabi & Gherekhloo 2015, Sohrabi *et al.* 2017).

This report and evaluation of two escaped species represent a call to action for relevant organizations, particularly the Iran Plant Protection and Organization of Environmental Protection, to enhance their monitoring of introduced species that are freely imported and cultivated for ornamental and medicinal purposes. Eradicating escaped species from uncultivated areas is feasible if prioritized by decision-makers for rapid removal. The results of the IUCN Environmental Impact Classification of Alien Taxa (EICAT-IUCN) and Socio-Economic Impact Classification of Alien Taxa (SEICAT) analysis revealed a significant data gap regarding the actual impact of the species in Iran, emphasizing the need to address this shortfall.

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Not Final