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Escape of *Coreopsis tinctoria* in northern Iran: Evidence from Guilan Province

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Abstract

During surveys of alien plants conducted in Guilan Province (northern Iran) from 2021 to 2026, eight ornamental species occurring outside cultivation were identified and monitored. Species identification was based on regional and international floras. Among these species, *Coreopsis tinctoria* exhibited the most pronounced spatial expansion and was the only taxon that developed multiple self-sustaining populations. *C. tinctoria*, an annual ornamental species native to North America, is widely cultivated for its attractive flowers. Escaped populations were recorded along roadsides, abandoned lands, drainage canals, urban margins, and disturbed grasslands, where they were mainly associated with ruderal vegetation. Field observations revealed different stages of establishment, ranging from isolated individuals and small colonies of up to 30 plants to large colonies comprising approximately 200 flowering individuals. The persistence of populations and successful seed reproduction over several consecutive years confirm the establishment of self-sustaining populations in the study area. The successful establishment of *C. tinctoria* is likely associated with its widespread ornamental cultivation, high reproductive capacity, and ability to colonize habitats disturbed by human activities. Compared with the other monitored ornamental species, *C. tinctoria* was the only species showing a clear pattern of escape from cultivation, successful establishment, and gradual spread across the region. This study provides the first documented record of the escape of *C. tinctoria* from cultivation in Iran and highlights the importance of monitoring escaped ornamental plants for the early detection of potentially invasive species in the Hyrcanian region.

Keywords: Alien flora, Asteraceae, naturalization, Hyrcanian region, ornamental plant, ruderal

گریز از کشت گل اشرفی در ایران: شواهدی از استان گیلان

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خلاصه

در بررسی‌های گیاهان غیربومی استان گیلان در سال‌های ۱۴۰۰ تا ۱۴۰۵، هشت گونه زینتی با قابلیت گریز از کشت به طور مستمر پایش شدند. شناسایی گونه براساس منابع معتبر فلوری منطقه‌ای و بین‌المللی انجام گرفت. از بین گونه‌های پایش‌شده، گل اشرفی توسعه فضایی چشمگیری نشان داد و چندین جمعیت خودپایا از آن ثبت شد. گل اشرفی (*Coreopsis tinctoria* Nutt.) از کاسنیان، گیاهی یک‌ساله و زینتی با خاستگاه آمریکای شمالی است که به دلیل گل‌های جذاب کشت می‌شود. این گونه در حاشیه جاده‌ها، اراضی متروکه، کانال‌های زهکشی، حاشیه مناطق شهری و علفزارهای تخریب‌شده مشاهده شد و غالبا با پوشش‌های گیاهی خرابه‌روی همراه بود. مشاهدات میدانی مراحل مختلف استقرار را نشان داد، به طوری که از افراد منفرد جدا افتاده و کلنی‌های کوچک با حداکثر ۳۰ پایه تا کلنی‌های بزرگ شامل حدود ۲۰۰ پایه گل‌دهنده مشاهده شدند. تداوم جمعیت‌ها و زادآوری موفق از طریق بذر در چندین سال متوالی، خودپایا شدن این گونه را در منطقه تأیید می‌کند. استقرار *C. tinctoria* با کشت گسترده زینتی، توان تولیدمثلی بالا و سازگاری آن با زیستگاه‌های تحت تأثیر فعالیت‌های انسانی مرتبط است. در مقایسه با سایر گونه‌های پایش‌شده، این گونه تنها گیاهی بود که روند آشکار گریز از کشت، استقرار موفق و گسترش تدریجی در سطح منطقه را نشان داد. مطالعه حاضر، نخستین گزارش مستند از گریز و استقرار خودپایای *C. tinctoria* در ایران را ارایه می‌کند و بر اهمیت پایش گیاهان زینتی گریز از کشت برای شناسایی زودهنگام گونه‌های بالقوه مهاجم در ناحیه هیرکانی تأکید دارد.

واژه‌های کلیدی: خرابه‌روی، طبیعی‌شدن، فلور غیربومی، کاسنیان، گیاهان زینتی، ناحیه هیرکانی

Introduction

Alien plant species are increasingly recognized as a major driver of global biodiversity change, particularly when they establish self-sustaining populations outside cultivation through a process known as naturalization (Richardson *et al*. 2000, Pyšek *et al*. 2020). The successful establishment of alien species is often promoted by propagule pressure, ecological adaptability, habitat disturbance, and climate change, all of which may create new opportunities for colonization and spread (van Kleunen *et al*. 2019, Essl *et al*. 2020). It is imperative to acknowledge the significance of early detection and monitoring of naturalized species, which are recognized as the primary source pool for future biological invasions. This is of particular importance for the conservation of biodiversity and the effective management of ecosystems (Blackburn *et al*. 2011).

Ornamental horticulture is one of the most important pathways for the introduction of alien plants worldwide (Dehnen-Schmutz & Touza 2008). Numerous ornamental species escape cultivation and establish spontaneous populations in disturbed habitats such as roadsides, abandoned lands, urban fringes, agricultural margins, and forest edges (Aikio *et al*. 2012). These anthropogenically disturbed habitats frequently act as invasion corridors, facilitating the establishment and spread of alien plants into adjacent semi-natural and natural ecosystems (Warren *et al*. 2013). Species characterized by prolific seed production, effective dispersal mechanisms, and broad ecological tolerance are particularly successful in colonizing such environments (van Kleunen *et al*. 2019).

The Hyrcanian region of northern Iran represents one of the most important temperate ecosystems in Western Asia and harbors exceptional levels of biodiversity and endemics with endangered conservation status (Ghorbanalizadeh & Akhani 2021, Pahlevani & Frajman 2023, Ghahremaninejad 2026). However, rapid urbanization, road construction, agricultural expansion, tourism development, and increasing landscape fragmentation have substantially altered many lowland Hyrcanian habitats during recent decades **(**Zarandian *et al.* 2016). Simultaneously, the widespread use of non-native ornamental plants in urban and rural landscapes has increased opportunities for the establishment of alien species. Accordingly, several alien plants (Tokasi *et al.* 2017, Bidarlord *et al.* 2019, Moradi & Hamzehee 2021, Bidarlord *et al*. 2023, Bidarlord & Hamzeh'ee 2023, Sohrabi *et al.* 2023, 2024, Khorasani *et al*. 2025) have been reported spreading spontaneously in disturbed habitats and forest margins of northern Iran, with evidence of increasing abundance and distribution.

Coreopsis tinctoria Nutt. (Asteraceae) is a North American species widely cultivated as an ornamental due to its attractive flowers and ease of cultivation (Smith 1977, Armitage 2011, USDA-NRCS 2024). The species has also been reported as naturalized outside its native range under favorable environmental conditions (Randall 2017, POWO 2026, GRIN-Global 2026). Given the ecological importance of the Hyrcanian region and the increasing occurrence of ornamental plant escapes, documenting the establishment status and evaluating the invasion potential of *C. tinctoria* are essential for the early detection and management of emerging alien species. Therefore, the objectives of this study were to document the occurrence of *C. tinctoria* in northern Iran, assess its naturalization status, and discuss its potential implications for biodiversity conservation in the Hyrcanian ecosystem.

Materials and Methods

As part of an ongoing monitoring program on alien and invasive plant species in Guilan Province (northern Iran), extensive field surveys were conducted from 2021 to 2026 across the lowland areas of the province. During these surveys, occurrences of alien plant species were recorded, and their distribution, habitat characteristics, and population status were documented.

Plant specimens were collected and identified using regional and international floristic references, including Flora Iranica (Rechinger 1963–2015), Flora of Iran (Assadi *et al*. 1988–2024), Flora of China (Wu

et al. 1994–2013), Weakley (2023), Flora of North America (Strother 2006), Flora of China (Shi & Robertson 2011), Plants of the World Online (POWO 2026), Global Biodiversity Information Facility (GBIF 2026), and other relevant taxonomic sources. Scientific names and author citations were verified using the International Plant Names Index (IPNI 2024) and the nomenclature followed Plants of the World Online (POWO 2026). Voucher specimens were deposited in the herbarium of the Agricultural and Natural Resources Research and Education Center of Guilan Province (Rasht, Iran).

Based on repeated observations over multiple years and following the definitions of Richardson *et al.* (2000) and Blackburn *et al*. (2011), the species is herein reported as a naturalized ornamental alien plant in northern Iran.

Results

During field surveys conducted in Guilan Province, eight ornamental alien plant species with the potential to escape from cultivation were recorded in a variety of disturbed habitats (Table 1). Most species were represented by one to five localized populations comprising fewer than 30 individuals, and their occurrence was largely confined to abandoned urban green spaces, residential vacant lots, roadsides, and other anthropogenically disturbed sites. Although flowering was observed in all species, evidence of successful recruitment or long-term persistence was generally limited. In contrast, *C. tinctoria* exhibited the widest distribution and the largest populations, with numerous localities supporting colonies of up to 200 individuals. Field observations documented all life-history stages, including seedlings, juvenile and mature vegetative plants, flowering and fruiting individuals, indicating successful recruitment and the formation of self-sustaining populations.

Table 1. Comparison of self-sustaining ornamental plant species with *Coreopsis tinctoria* based on population size and evidence of establishment in Guilan Province (northern Iran)

Taxon	Habitat where self-sustaining population were recorded	Representative locality	No. of population	Estimated population size	Reproductive evidence
Cosmos sulphureus Cav.	Roadsides and disturbed habitats	Rasht, Rudsar	3	< 30 individuals per population	Flowering and fruiting observed
Datura inoxia Mill.	Abandoned land around residential areas	Bujagh National Park; Kiashahr; Chamkhaleh	2	2–3 individuals per population	Flowering and fruiting observed
Dimorphotheca ecklonis DC.	Neglected urban green spaces	Rasht (Lakan); Lahijan-Langarud; Hashtpar-Asalem; Rasht (Fakhab); Masal	5	Fewer than 10 individuals per population	Flowering observed; no recruitment detected
Oenothera speciosa Nutt.	Roadsides and disturbed habitats	Pir Bazar, Chamkhaleh, Kiashahr	3	< 30 individuals per population	Flowering observed; vegetative persistence
Petunia axillaris (Lam.) Britton, Sterns & Poggenb.	Disturbed urban green spaces and abandoned land	Anzali (Siah Khaleh Sar Village); Rasht (Lakan); Pir Bazar-Fakhab	3	< 20 individuals per population	Flowering observed; seedlings recorded
Tagetes minuta L.	Margins of urban green spaces and disturbed land	Shalman-Amlash; Bujagh National Park	2	< 20 individuals	Flowering and fruiting observed
Tropaeolum majus L.	Abandoned land surrounding residential areas	Chamkhaleh, Kiashahr, Saravan, Fuman, Masal	5	Small populations (< 30 individuals)	Flowering observed; limited persistence
Coreopsis tinctoria Nutt.	Roadsides, abandoned land, urban margins and disturbed habitats	Widespread throughout Guilan Province (Table 2)	+15	Up to 200 individuals per population; several large, self-sustaining colonies	Seedlings, juvenile and mature vegetative plants, flowering and fruiting individuals recorded

- Taxonomic treatment

Coreopsis tinctoria Nutt., J. Acad. Nat. Sci. Philadelphia. 2: 114 (1821) (Fig. 1)

Syns: *Bidens tinctoria* (Nutt.) E.H.L.Krause *In*: J.W.Sturm, Deutschl. Fl. Abbild., ed. 2. 13: 157 (1905); *Calliopsis tinctoria* (Nutt.) DC. *In*: Prodr. 5: 568 (1836); *Diplosastera tinctoria* (Nutt.) Tausch *In*: Hort. Canal.: t. 4 (1823)

Annual herb, 30–100 cm tall. Stems erect, branched, glabrous to sparsely pubescent. Leaves opposite, pinnatisect to bipinnatisect with narrow linear segments, terminal lobes lance-ovate to oblanceolate, 10–60 × 5–25 mm; cauline blades usually 1–2(–3)-pinnate, rarely simple, simple blades or terminal lobes lance-linear to linear or filiform, 10–45 × 0.5–2(–5) mm. Peduncles 1–5(–15) cm. Capitula solitary or arranged in loose corymbs; involucres ± globose to cylindric, 7–15 mm in diam; Phyllaries ± lance-oblong to lance-ovate, 4–7(–9) mm. Calyculi of deltate-lanceolate bractlets 1–3 mm. Ray florets usually 8, sterile, yellow with reddish-brown markings at the base rarely yellow throughout, 12–18 mm; Disc florets 2.5–3 mm, corolla lobes 4, dark reddish-brown, style-branch apices ± truncate. Achenes compressed, blackish, 1.5–3(–4) mm, papillate to tuberculate; pappus absent, bearing two short awns, 0.1–0.5 mm.

Flowering and Fruiting: June–August.

Distribution and habitat: During surveys conducted between 2021–26, *C. tinctoria* was recorded from several localities in the lowland areas of Guilan Province (Table 2). Populations were observed along roadsides, drainage channels, abandoned lands, urban fringes, and disturbed grasslands. Representative localities included Amlash, Bandar-e Anzali, Fuman, Kiashahr, Rasht, Rezvanshahr, Shalman, and Ziabar (Fig. 2). Most populations occurred in open, highly disturbed habitats exposed to full sunlight and subject to regular anthropogenic disturbance.

The species was frequently associated with ruderal vegetation dominated by *Bidens frondosa* L., *Sorghum halepense* (L.) Pers., *Erigeron annuus* (L.) Desf., *E. canadensis* L., *Paspalum dilatatum* Poir., and other alien or disturbance-tolerant species. The current distribution pattern indicates that, the species is primarily concentrated within the lowlands of Guilan Province. The known distribution of the species in the study area is presented in figure 2.

Coreopsis tinctoria is widely grown in public and residential gardens, and commercially (for cut flowers), and has become vastly established in the area.

Population status: Field observations revealed populations at different stages of establishment. Small and apparently recent populations consisted of (5)10–30 flowering individuals scattered along road margins, whereas larger populations contained between 100 and 200 individuals occupying continuous stretches of roadside vegetation and abandoned lands. These populations were regarded as escaped rather than cultivated because they occurred outside gardens and managed landscapes, were established in unmanaged habitats, showed irregular spatial distribution, and were associated with spontaneous ruderal vegetation. No evidence of intentional planting, horticultural maintenance, or landscape management was observed at any of the sites. Several populations persisted over consecutive years and exhibited successful regeneration through seed production without evidence of deliberate planting (Fig. 3).

The increasing number of occupied localities and the occurrence of multiple self-sustaining populations indicate that, *C. tinctoria* has successfully escaped cultivation and established naturalized populations in northern Iran. The species currently occurs as scattered but expanding populations, particularly in disturbed lowland habitats where suitable conditions for recruitment and dispersal are available.

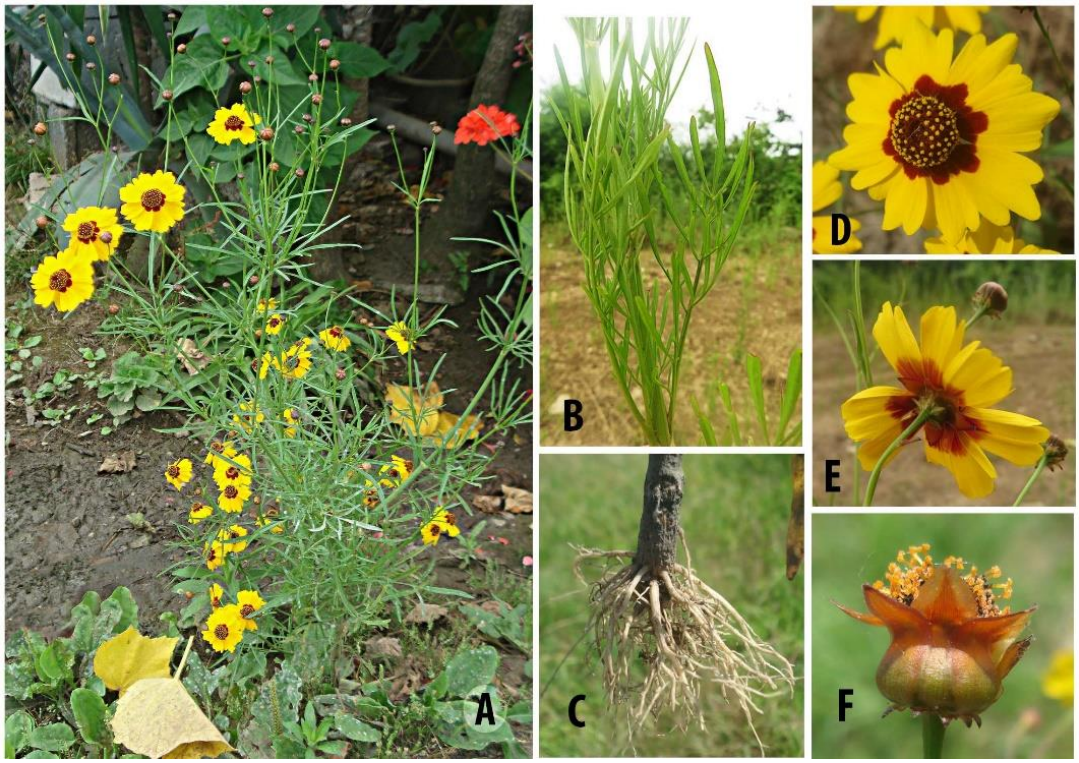

Fig. 1. *Coreopsis tinctoria*: A. Habit, B. Leaves, C. Root system, D. Capitulum (front view), E. Capitulum (back view), F. Phyllaries.

Table 2. Distribution, recorded point and habitats of *Coreopsis tinctoria* in Guilan Province (northern Iran), based on field surveys conducted between 2021–26

Locality	Coordinates	Altitude (m a.s.l.)	Habitat
Resvanshahr, Haft Daghanan Forest	37°28'57" N, 49°11'28" E	3	Roadside, abandoned field
Ziabar-Amandan Village	37°25'15" N, 49°14'59" E	-15	Roadside, abandoned field
Pirbazar to Ziabar	37°20'43" N, 49°27'52" E	-22	Roadside
Fuman-rasht, Agha Seyed Sharif	37°12'51" N, 49°25'21" E	14	Abandoned field
Sangar, Shahrestan	37°25'15" N, 49°47'48" E	-23	Garden
Sangar, Chanal	37° 8'10" N, 49°41'44" E	42	Abandoned field
Rasht to Khomam, Mesr-Dasht Village	37°21'8" N, 49°38'22" E	-8	Abandoned field
Shalman to Amlash	37° 6'43" N, 50°13'49" E	-4	Roadside
Chamkhale	37°15'58" N, 50°14'13" E	-24	Abandoned field
Kashal-varzal Village	37°11'27" N, 49°38'52" E	32	Abandoned field
Siahkal, Pashaki Village	37° 9'17" N, 49°48'4" E	31	Roadside
Paresar	37°35'58" N, 49° 2'48" E	30	Abandoned field
Bandar-e Anzali, Shile Sar Village	37°31'20"N, 49°13'23"E	-18	Abandoned field
Bandar-e Anzali, Turba Bar Village	37°28'30"N, 49°18'16"E	-24	Roadside
Amlash-Rankuh	37°10'16"N, 49°42'13"E	32	Abandoned field

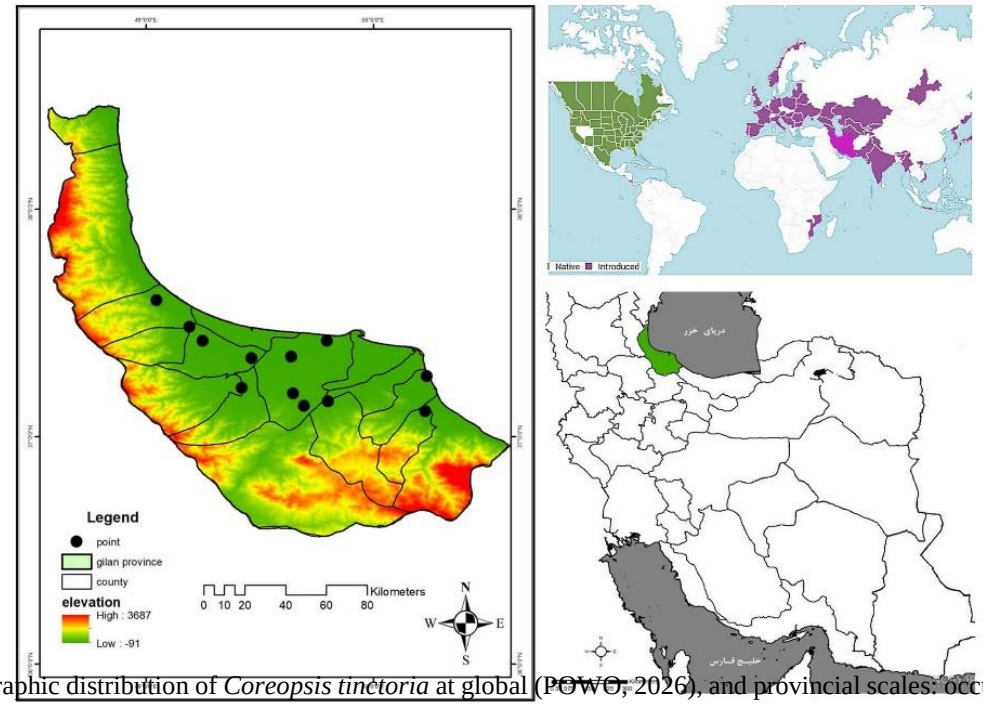

Fig. 2. Geographic distribution of *Coreopsis tinctoria* at global (POWO, 2026), and provincial scales: occurrence records in Guilan Province (northern Iran) based on field surveys conducted during 2021–26.

Fig. 3. Several populations of *Coreopsis tinctoria* in Guilan Province (northern Iran).

Discussion

The present study provides the first documented evidence that *C. tinctoria* has established self-sustaining populations outside cultivation in northern Iran. The persistence of populations over multiple years and successful recruitment indicate that, the species fulfils the criteria for naturalization proposed by Richardson *et al*. (2000). Furthermore, the observed variation in population size and structure suggests that, *C. tinctoria* has progressed beyond the casual stage of the introduction process, consistent with the unified invasion framework of Blackburn *et al*. (2011).

The escape of *C. tinctoria* is most likely associated with its widespread ornamental cultivation, as ornamental horticulture represents one of the principal pathways for the introduction and naturalization of alien plants worldwide (Dehnen-Schmutz & Touza 2008, van Kleunen *et al*. 2019). The successful establishment of the species in Guilan Province further suggests that, habitats subjected to frequent human disturbance, such as roadsides, abandoned land, drainage channels, and urban margins, provide favorable conditions for the persistence and spread of escaped ornamental plants, a pattern widely reported for naturalized alien species (Richardson *et al*. 2000, Warren *et al*. 2013).

A comparison with the other escaped ornamental species monitored during the present study further supports the naturalization status of *C. tinctoria*. Although several ornamental species escaping from cultivation were also recorded in Guilan Province, their populations remained small and localized, with only limited evidence of persistence or recruitment (Table 1). In contrast, *C. tinctoria* was the only species that consistently exhibited clear evidence of population persistence, successful regeneration, and progressive spread across multiple localities. These observations reinforce the view that escape from cultivation alone is insufficient for naturalization, as only a small proportion of introduced ornamental plants successfully overcome establishment barriers and develop self-sustaining populations (Richardson *et al*. 2000, Blackburn *et al*. 2011). The comparison also highlights the importance of long-term monitoring of escaped ornamental plants for distinguishing casual escapes from genuinely naturalized species and for the early detection of taxa with future invasion potential (Essl *et al*. 2020).

At present, *C. tinctoria* appears to be restricted to disturbed lowland habitats, with no evidence of establishment in natural or semi-natural ecosystems of the Hyrcanian region. According to the unified invasion framework proposed by Blackburn *et al*. (2011), the available evidence indicates that, the species has reached the naturalized stage but cannot yet be regarded as invasive. Nevertheless, its persistence over multiple years and the increasing number of recorded localities suggest that, the naturalization process is ongoing, highlighting the need for continued monitoring.

Many ornamental alien plants remain confined to disturbed habitats for prolonged periods before some undergo rapid range expansion following a lag phase (Essl *et al*. 2020). Although the future invasion potential of *C. tinctoria* remains uncertain, its successful naturalization highlights the importance of early detection and continued monitoring. The humid climate of Guilan Province and frequent habitat disturbance may facilitate further spread of the species, emphasizing the need to include newly naturalized ornamental plants in regional monitoring programs (Richardson *et al*. 2000, Essl *et al*. 2020).

In conclusion, *C. tinctoria* represents a newly escaped ornamental species that has become naturalized in northern Iran. Comparative monitoring of escaped ornamental plants identified *C. tinctoria* as the only species showing clear evidence of successful transition from escape to naturalization, emphasizing the importance of long-term surveillance for distinguishing casual escapes from genuinely naturalized species. Continued monitoring will be essential for evaluating its future spread and supporting the early detection and management of potential plant invasions in the Hyrcanian region.

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