

Rapid Communication

***Tarenaya spinosa* (Jacq.) Raf. (Cleomaceae): a new addition to the naturalized alien flora of Iran**Mina Khorasani¹, Alireza Naqinezhad², Raimundo Luciano Soares Neto³ and Giuseppe Brundu^{4,5}¹Department of Biology Education, Farhangian University, P.O. Box 14665-889, Tehran, Iran²Department of Environmental Sciences, College of Science and Engineering, University of Derby, Kedleston Road, Derby, DE22 1GB, United Kingdom³Department of Botany and Zoology, Biosciences Centre, Federal University of Rio Grande do Norte, 59078-900, Natal, Rio Grande do Norte, Brazil⁴Department of Agricultural Sciences, University of Sassari, Viale Italia 39/A, 07100 Sassari, Italy⁵National Biodiversity Future Centre, Palermo, Piazza Marina 61, 90133 Palermo, Italy

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Abstract

We report the first record of *Tarenaya spinosa* (Jacq.) Raf. (spiny spider flower) as a new addition to the naturalized alien flora of Iran. Spiny spider flower is native to South and Central America and widely naturalized in the paleo-tropics (south Africa and Asia). This species was intentionally introduced to Iran in the last decade of the XX century and cultivated as an ornamental plant due to its large, peculiar, and colorful flowers. It escaped from cultivation and gradually increased its alien range in the surrounding areas, by seeds, without any direct human intervention. The UNESCO-world-heritage site Hyrcanian forests (northern Iran) includes a unique forest ecosystem which is potentially threatened by the naturalization of many alien and invasive species including this new recorded alien. Considering the potential negative impacts of this new alien species on the native biodiversity and its high reproductive potential and spread capacity, we highlight the importance of preventing new introductions, and prioritizing practices for eradication and control before it could become widespread and unmanageable.

Key words: first record, annual herb, *Cleome*, escape, neotropical alien plant, ornamental plant

Introduction

Tarenaya Raf., one of the largest genera within the family Cleomaceae Bercht. & Presl, can be neatly distinguished from its closest *Cleome* L. by morphological diagnostic traits such as stipular thorns, petiolar spines, lack of arils, and seeds with a large cleft cavity (Zhang and Tucker 2008; Tucker and Vanderpool 2010; Roalson and Hall 2017). The genus *Tarenaya* includes about 38 species, with primarily a neotropical distribution, and only one disjunct and endemic species occurring in Central Africa, *T. afrospina* (Iltis) Soares Neto & Roalson (Soares Neto et al. 2022a). Several species of this genus have been introduced worldwide in tropical and warm-temperate biomes, such as *T. houtteana* (Schltdl.) Soares Neto & Roalson (syn. *Cleome hassleriana* Chodat) (Zhang and Tucker 2008; Tucker and Iltis 2010),

T. diffusa (Banks ex DC.) Soares Neto & Roalson (Soares Neto et al. 2022a), and *T. spinosa* (Jacq.) Raf. (syn. *Cleome spinosa* Jacq.) (Jafri 1973; Soares Neto et al. 2022a).

Tarenaya spinosa (Jacq.) Raf. (spiny spider flower) is an annual herb native to South and Central America (Belize, Bolivia, Colombia, Costa Rica, Ecuador, French Guiana, Guatemala, Guyana, Honduras, Nicaragua, Panamá, Peru, Salvador, Suriname, and Venezuela; POWO 2024) that grows along roadsides, riverbanks, within coastal vegetation, meadows, open forests, and ruderal habitats from 0–1000 m a.s.l. (Tucker and Iltis 2010; Soares Neto et al. 2022a). In recent years, the species has been introduced as an ornamental plant in many other parts of the world, and has been reported as naturalized in the paleo-tropics, such as in South and in Central Africa (Angola, Cameroon, Congo, and Gabon, Nigeria: Hauman and Wilczek 1951; POWO 2024), and south, southeast and east of Asia (India, Korea, Nepal, Pakistan, and Vietnam: Jafri 1973; Riaz et al. 2019; POWO 2024; EPPO 2024), as well as in North America (Mexico, USA, and West Indies: POWO 2024). Moreover, it is recorded as a casual alien species in Europe (Bosnia and Herzegovina, Croatia, and Italy: Euro+Med 2024). Importantly, the misapplication of the name *Cleome spinosa* in the labels of many herbarium specimens for many neotropical *Cleome* species caught the attention of Iltis (1952) during his comprehensive review of the New World *Cleome* (Soares Neto et al. 2019). As a result, *Tarenaya hassleriana* and *T. houtteana*, cultivated as ornamental plants world-wide, are the species most frequently wrongly identified as *T. spinosa*.

During a study aiming to achieve a taxonomic revision of Cleomaceae for Iran (*unpublished*), we detected several populations of the alien *Tarenaya spinosa* in moist open forests, roadsides, gardens, as well as ruderal and wet habitats along the Hyrcanian forests. Therefore, we report these findings and provide a complete description of this alien plant's main morphological diagnostic features, original distribution data, and discuss potential threats and management options.

Materials and methods

Fieldwork was carried out in the Hyrcanian forests of northern Iran (around the Guilan and Mazandaran provinces) in April–October 2020. During our field surveys, several populations of the new alien plant *Tarenaya spinosa* were observed for the first time growing in abandoned gardens, roadsides, moist open forests, and ruderal sites (Figure 1). Two highly invaded sites were monitored in the period 2020–2023 to assess the persistence and naturalization of these populations. The species was identified according to the dichotomous key of Soares Neto et al. (2022a) and cross checking the morphological descriptions of several floras, such as the Flora of Central Africa (Hauman and Wilczek 1951), the Flora of Pakistan (Jafri 1973), the Flora of North America (Tucker and Iltis 2010; Tucker and Vanderpool

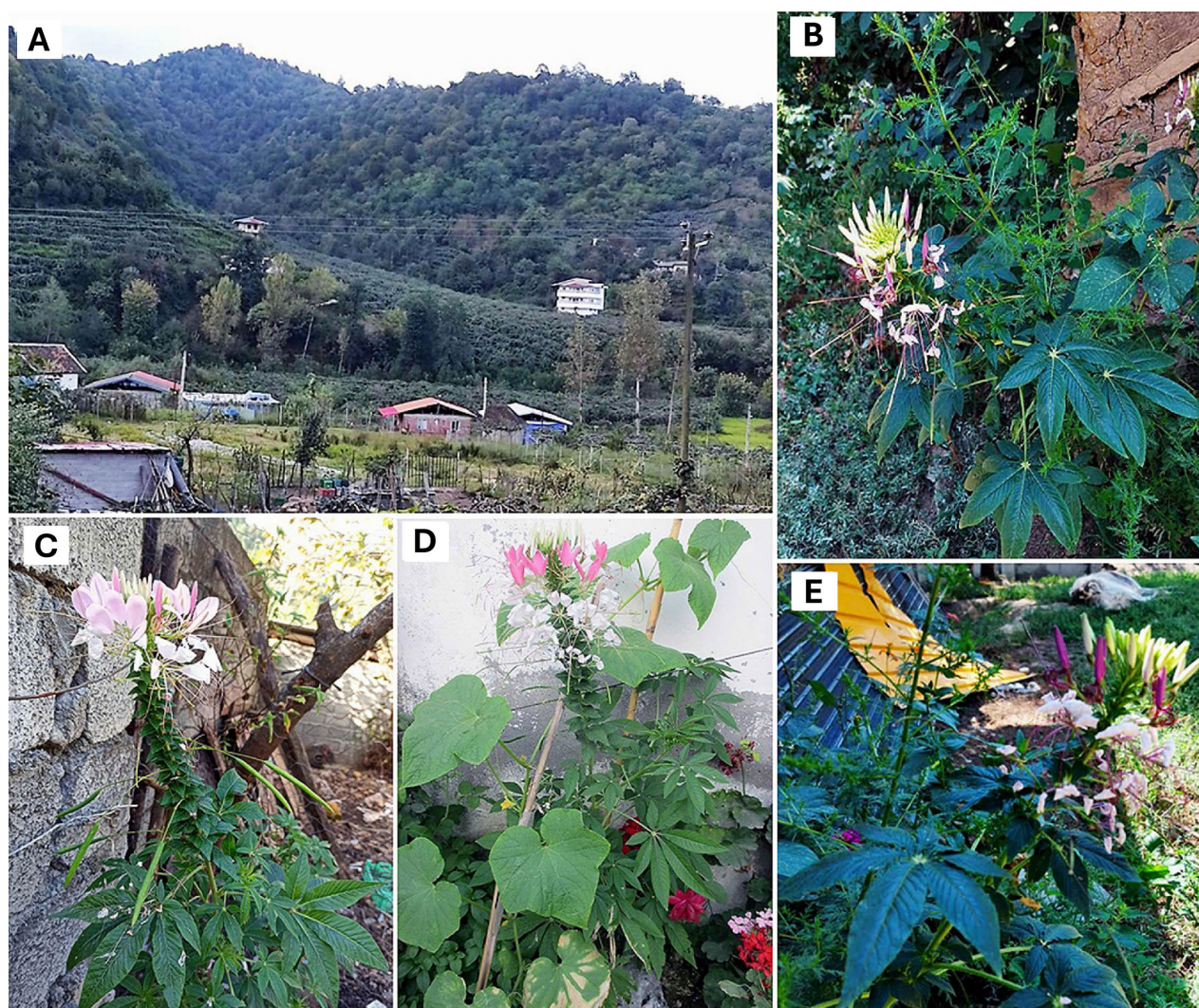


Figure 1. In the top left corner (A) a view of the area invaded by *Tarenaya spinosa* (Jacq.) Raf.; clockwise images of plants in different ruderal habitats (B, C, D, and E). Photos by M. Khorasani.

2010), and other reliable literature, such as, Soares Neto et al. (2019, 2022b) and Riaz et al. (2019). In addition, virtual herbarium catalogues of BM, BR, G, K, M, MO, NY, VT, and W herbaria were studied via the Global Biodiversity Information Facility (GBIF 2024; <https://www.gbif.org/>), and the Global Plants database (JSTOR 2024; <https://plants.jstor.org/>).

The main morphological diagnostic features of the collected specimens were observed using a stereomicroscope (Nikon SMZ645 model) (Figure 2A–D). The seed surface ultrastructure, being an important trait for the identification of *T. spinosa* (Sánchez-Acebo 2005; Riaz and Abid 2018) and for distinguishing it from *T. houtteana* (Schltdl.) Soares Neto & Roalson, was examined by scanning electron microscope (Hitachi SU3500, Hitachi Ltd., Tokyo, Japan) (Figure 2E–F). The voucher samples were preserved at the University of Mazandaran Herbarium (HUMZ, 9114).

In addition, the global distribution range of *T. spinosa* was assessed by integrating different sources such as the Euro+Med-Checklist (Euro+Med 2024; <https://euromed.org/>), the EPPO Global Database (EPPO 2024;

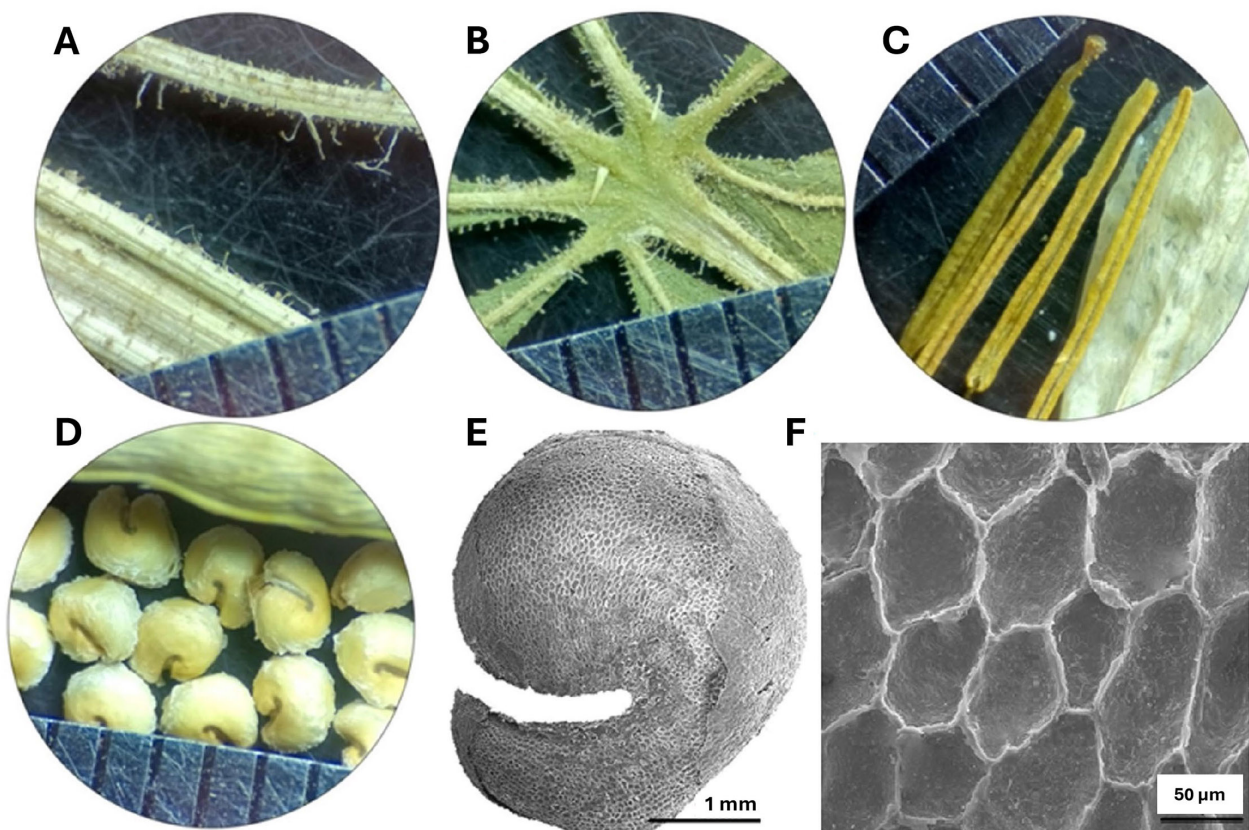


Figure 2. Stereomicroscope photographs of *Tarenaya spinosa* (Jacq.) Raf. (A–D) showing stem and branch surface with densely stalked-glandular and simple hairs (A); stipular spines and spines (prickles) at leaf base (B); elongated-linear ovary and short style (C); seeds sub-pyriform-ovate or roundish, and glabrous (D). Scanning electron micrographs of seed and seed surface ultrastructure (E–F) showing rectangular cleft (E); reticulate surface (F). Photos by M. Khorasani.

<https://gd.eppo.int/taxon/RUMPL>), POWO (POWO 2024; <https://powo.science.kew.org/>), the Global Biodiversity Information Facility (GBIF 2024; <https://www.gbif.org/>), iNaturalist (2024), the Global Register of Introduced and Invasive Species – GRIIS (Keshavarzi et al. 2020), and available literature. Although several web sites (e.g., POWO) include Brazil in the native range of this species, we excluded this country from *T. spinosa* native range based on Soares Neto et al. (2019, 2022b).

Results and discussion

Tarenaya spinosa (Jacq.) Raf., Sylva Tellur. 111 (1838)

(Figures 1–3)

Main synonyms: ≡ *Cleome spinosa* Jacq., Enum. Syst. Pl. 26 (1760); ≡ *Neocleome spinosa* (Jacq.) Small, Man. S.E. Fl. 577 (1933); = *Cleome heptaphylla* L., Sp. Pl. (ed. 2) 2: 987 (1763); = *Cleome erucago* Mill., Gard. Dict., ed. 8: *Cleome* n. 6 (1768); = *Cleome pubescens* Sims, in Bot. Mag. 43: pl. 1857. (1816); = *Cleome tonduzii* Briq., Annuaire Conserv. Jard. Bot. Genève 17: 375 (1914). Type: Jamaica. N. Jacquin s.n. (neotype, designated by Al-Shehbaz [1988: 305], BM not seen).

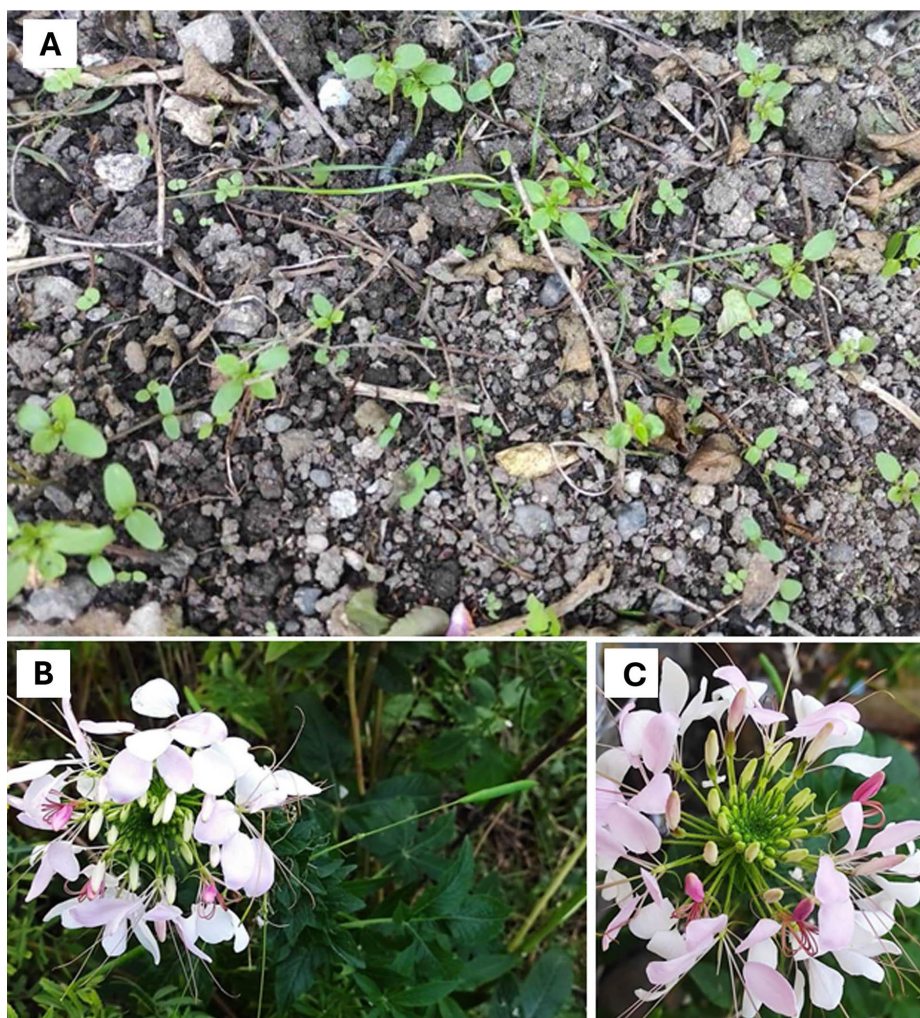


Figure 3. *Tarenaya spinosa* (Jacq.) Raf. showing its seedlings in the natural habitat (A); and flowers and fruits (B and C). Photos by M. Khorasani.

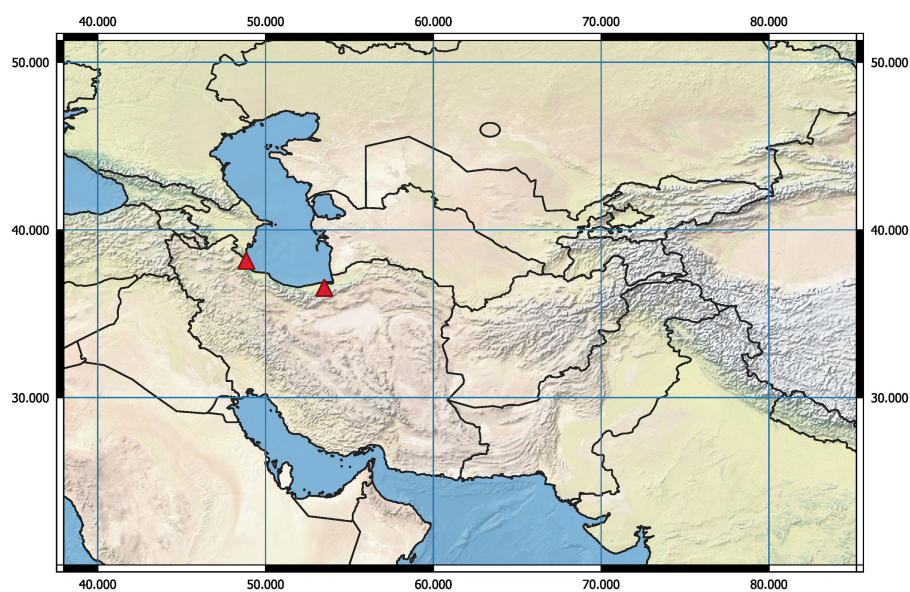


Figure 4. Map showing the location in Northern Iran of the two main invaded sites (Guilan Province: Talesh, Chubar toward Vosi village, and Mazandaran Province: Amol, Ghaemie-Olia village). Background map made with Natural Earth, Free vector and raster map data @naturalearthdata.com.

Species description

Herbs or subshrubs, 40–90 (170) cm tall, green. Stems branched, densely stalked-glandular and simple hairy. Leaves compound, 5–7-foliolate, glandular and eglandular indumentum, slightly spiny, 1-nerved, present of a pair of minute spiny stipules at leaf base; leaflets ovate-oblong, apex acute, attenuate-cuneate at base, ca. 20–53 × 3–13 mm; petiole long, thick, glandular, and simple hairy, 10–50 mm. Inflorescences dense, conspicuously bracteate. Flowers bisexual, large, bearing some disc appendages; pedicels long, up to 20 mm; sepals linear-ovate, apex acute, densely glandular, ca. 5–6 × 0.9–1 mm; petals oblong-elliptic to obovate, apex obtuse, unappendaged, white-pinkish, long, about twice as long as the sepals, 10–13 × 3–6 mm; claws long, ca. 6–10 mm; stamens 6–7; filaments glabrous, purple, nearly 2 times as long as the petals, 10–27 mm long; anthers yellow, elongated, ca. 6–8 mm; ovary elongated-linear, glabrous, 5–7 mm; gynophore long, ca. 10–27 mm; androgynophore absent; style short, 0.8–1 mm long or absent, stigma capitate. Fruits linear or cylindric, acute, stipitate. glabrous to rarely glandular hairy, ca. 50–60 × 3–5 mm; stipes very elongated, ca. 50–70 mm; peduncles erect, 30–35 mm long. Seeds sub-pyriform-ovate or roundish with a wide rectangular groove (large cleft cavity), angular, reticulate surface, brown, and yellowish green in unripe seeds, glabrous, up to 2 mm in diameter.

Habitat and distribution in Iran

North Iran: Guilan Province: Talesh, Chubar toward Vosi village, in gardens, roadsides, moist open forests, and ruderal habitats, 60–700 m a.s.l., 38°10'16.50"–38°10'34.16"N; 48°51'18.60"–48°48'35.13"E, April–September (October) 2020–2023 (M. Khorasani *personal observation*); Mazandaran Province: Amol, Ghaemie-Olia village, in moist soils of gardens, and roadsides, 6 m b.s.l., 36°33'30.91"N; 52°30'6.59"E, April–October 2020–2023, M. Khorasani 9114 (HUMZ).

The two main invaded sites are located within a radius of ca. 445 km and are found along the Hyrcanian forests, as a unique deciduous forest ecosystem in the north of Iran, which is a UNESCO World Heritage site harboring invaluable relicts of Tertiary floristic elements (Naqinezhad et al. 2021; Ghorbanalizadeh and Akhane 2022). At each site, small populations of the new alien, ranging in size from 1 to 3 m², were observed. Spiny spider flower spreads in moist open forests habitats, due to the presence of suitable conditions for growth in terms of temperature and humidity. It flowers and bears fruits in April–September (October). Spiny spider flower also thrives in ruderal habitats close to the two main invaded areas (Figure 1A–C), where a large number of seedlings can be observed each year, particularly in gardens (up to 50 seedlings m⁻²), while lower densities are observed outside gardens. It grows with other associated plants such as *Artemisia annua* L., *Chenopodium album* L., *Cynodon dactylon* (L.) Pers., and *Urtica dioica* L.

Table 1. Morphological comparisons between *Tarenaya spinosa* and its closest relative *T. houtteana* based on main diagnostic traits (adapted from Soares Neto et al. 2022a).

Diagnostic trait	<i>T. spinosa</i>	<i>T. houtteana</i>
Petal size (mm)	10–13 × 3–6	18–20 × 7–8
Petal color	white-pinkish	pink to purple, rarely white
Gynophore length (mm)	10–27	40–80
Pedice length (mm)	up to 20	20–50
Indumentum type of fruit	glabrous to rarely glandular hairy	glabrous

Tarenaya spinosa is morphologically distinct from other taxa of the family Cleomaceae, due to leaflet number, presence of spiny stipules, size and color of flower, as well as length of filament and gynophore (Jafri 1973; Hauman and Wilczek 1951; Tucker and Iltis 2010; Riaz et al. 2019; Soares Neto et al. 2022a). Besides, the species was recently distinguished against its close relative, *T. houtteana* (Schltdl.) Soares Neto & Roalson (syn. *Cleome hassleriana*) based on the color and size of petals, length of gynophore and pedicel, and indumentum type of fruit, as shown in Table 1 (Zhang and Tucker 2008; Soares Neto et al. 2022a).

Based on our field observations, *T. spinosa* represents a new addition to the naturalized alien flora of Iran, that so far lists 311 alien plant species, with 131 casual, 167 naturalized, and 13 alien invasive species (Sohrabi et al. 2023). The exact date of the first introduction of *T. spinosa* in Iran is unknown but after interviewing the people living in the study area, we assumed that at least since the last decade of the XX century the species had been cultivated in moist and sandy habitats (viz. gardens, yards, and along roads), as an ornamental plant due to its large and beautiful flowers (Mozaffarian 2018). Later, it escaped from cultivation and underwent a secondary spread facilitated by road constructions, cultivation of rice, grazing animals, pets, and travelers. Currently, it can reproduce via abundant seeds left over from previous years, and it is constantly reintroduced in cultivation as its seeds are sold in the herbal shops in the north of Iran. Furthermore, it is commonly sold as a plant for planting in flower shops and propagated by the residents.

To date, *T. spinosa* is mainly a ruderal plant both in its native and alien range. It should be noted that although there are many records of casual and naturalized populations world-wide, information on threats and potential or actual impacts is very scarce. However, it is considered a weed in several parts of its alien and native range (e.g., Giulietti et al. 2018; Leopardi-Verde et al. 2021) where it can colonize also wetlands, which are generally regarded as highly invisable habitats, resulting in impacts that are extremely costly in both economic and ecological terms (Hovick et al. 2023).

We underline the importance of a dedicated action plan for *T. spinosa* in Iran, to prevent new introductions, control the spread, and actively remove the first naturalized populations. Raising awareness among local communities about the detrimental effects of this alien plant on native ecosystems is an effective strategy to be included in the action plan. By educating residents on the importance of weeding out *T. spinosa* from gardens, forest margins,

rice fields, and roadsides, we can harness collective action toward its control. Moreover, the use of Spiny spider flower as an ornamental or honey species should be discouraged, particularly in the north of Iran, as it might expand its distribution to higher elevations within the conservation-important area of the Hyrcanian forests (Naqinezhad et al. 2021; Ghorbanalizadeh and Akhani 2022). An additional desirable phytosanitary measure that can significantly reduce the risk of spread, would be to implement a ban on the sale of plants of *T. spinosa* in flower shops and of its seeds in herbal shops. Collaborating with environmental organizations is crucial, particularly when Spiny spider flower threatens critical habitats, such as the Hyrcanian forests. Reporting sightings and infestations to environmental authorities can prompt targeted eradication efforts, combining local knowledge with expert interventions. Together, all these strategic actions should be included in the dedicated action plan to combat the proliferation of this alien plant and promote the conservation of native biodiversity and ecosystem services in Iran.

Authors' contribution

MK: has made substantial contributions to research conceptualization, sample design and methodology, investigation and data collection, taxonomic examination and interpretation, and writing the original draft, and editing. AN: has made substantial contributions to research conceptualization, data analysis and interpretation, writing, review, and editing. RLSN: has made substantial contributions to taxonomic and nomenclatural analysis and interpretation, review, and editing. GB: has made substantial contributions to data analysis and interpretation, writing, review, and editing. All authors have given final approval of the version to be published.

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