Invasive Plant Science and Management

www.cambridge.org/inp

Invasion Alert

Cite this article: Roxo G, Silva L, Borges Silva L, Rego R, Resendes R, and Moura M (2024) Early detection of *Youngia japonica* (L.) DC. (Asteraceae) in São Miguel Island, Azores, Portugal. Invasive Plant Sci. Manag **17**: 3–8. doi: 10.1017/inp.2023.32

Received: 27 July 2023
Revised: 23 October 2023
Accepted: 6 December 2023
First published online: 8 January 2024

Associate Editor:
Stephen F. Enloe, University of Florida

Keywords:
New introductions; *Youngia*

Corresponding author:
Guilherme Roxo;
Email: guilherme.g.roxo@uac.pt

Early detection of *Youngia japonica* (L.) DC. (Asteraceae) in São Miguel Island, Azores, Portugal

Guilherme Roxo[1], Luís Silva[2], Lurdes Borges Silva[3], Rúben Rego[4], Roberto Resendes[5] and Mónica Moura[6]

[1]Ph.D Student, CIBIO, Centro de Investigação em Biodiversidade e Recursos Genéticos, InBIO Laboratório Associado, Pólo dos Açores, Universidade dos Açores, Campus de Ponta Delgada, Ponta Delgada, Açores, Portugal; BIOPOLIS Program in Genomics, Biodiversity and Land Planning, CIBIO, Campus de Vairão, Vairão, Portugal; [2]Associate Professor, CIBIO, Centro de Investigação em Biodiversidade e Recursos Genéticos, InBIO Laboratório Associado, Pólo dos Açores, Universidade dos Açores, Campus de Ponta Delgada, Ponta Delgada, Açores, Portugal; BIOPOLIS Program in Genomics, Biodiversity and Land Planning, CIBIO, Campus de Vairão, Vairão, Portugal; [3]UNESCO Chair–Land within Sea: Biodiversity and Sustainability in Atlantic Islands, Faculdade de Ciências e Tecnologia, Universidade dos Açores, Campus de Ponta Delgada, Ponta Delgada, Açores, Portugal; Researcher, CIBIO-Azores, Universidade dos Açores, Ponta Delgada, Portugal; CIBIO, Centro de Investigação em Biodiversidade e Recursos Genéticos, InBIO Laboratório Associado, Pólo dos Açores, Universidade dos Açores, Campus de Ponta Delgada, Ponta Delgada, Açores, Portugal; BIOPOLIS Program in Genomics, Biodiversity and Land Planning, CIBIO, Campus de Vairão, Vairão, Portugal; [4]Ph.D Student, CIBIO-Azores, Universidade dos Açores, Ponta Delgada, Portugal; CIBIO, Centro de Investigação em Biodiversidade e Recursos Genéticos, InBIO Laboratório Associado, Pólo dos Açores, Universidade dos Açores, Campus de Ponta Delgada, Ponta Delgada, Açores, Portugal; BIOPOLIS Program in Genomics, Biodiversity and Land Planning, CIBIO, Campus de Vairão, Vairão, Portugal; [5]Herbarium Technician, CIBIO-Azores, Universidade dos Açores, Ponta Delgada, Portugal; CIBIO, Centro de Investigação em Biodiversidade e Recursos Genéticos, InBIO Laboratório Associado, Pólo dos Açores, Universidade dos Açores, Campus de Ponta Delgada, Ponta Delgada, Açores, Portugal; BIOPOLIS Program in Genomics, Biodiversity and Land Planning, CIBIO, Campus de Vairão, Vairão, Portugal and [6]Associate Professor, CIBIO-Azores, Universidade dos Açores, Ponta Delgada, Portugal; CIBIO, Centro de Investigação em Biodiversidade e Recursos Genéticos, InBIO Laboratório Associado, Pólo dos Açores, Universidade dos Açores, Campus de Ponta Delgada, Ponta Delgada, Açores, Portugal; BIOPOLIS Program in Genomics, Biodiversity and Land Planning, CIBIO, Campus de Vairão, Vairão, Portugal

Abstract

Youngia japonica (L.) DC. was recently discovered on the Azorean island of São Miguel. This species is a cosmopolitan herb that has been reported to be invasive in several regions of the world. It is unclear when and how this plant arrived in São Miguel, Azores. Nevertheless, we hypothesize that this is an unintentional and recent introduction. The populations are expanding in São Miguel, and action is needed to mitigate potential damage to native ecosystems.

Introduction

The genus *Youngia* Cass. (Asteraceae) comprises circa 40 species (POWO 2023; Shi and Kilian 2011) that are native to warm temperate and tropical eastern Asia (Shi and Kilian 2011). This genus is closely related to *Lapsana* L. and *Crepis* L. phylogenetically and morphologically (Slanis and Perea 2011). Morphologically, *Youngia* differs from *Crepis* by possessing compressed, unequally ribbed achenes, and from *Lapsana* by the presence of a pappus (Figure 1). *Youngia japonica* (L.) DC. is the most widely distributed species of the genus. In fact, its native range includes China, India, Japan, Korea, the Malay Peninsula, the Philippines, and Taiwan (Ling and Shih 1997). It has been introduced to five continents: Africa, South and North America, Australia, and Europe (Acevedo-Rodríguez and Strong 2007; Pagad et al. 2018; Pyke 2016). *Youngia japonica* is becoming an invasive weed worldwide, having established itself in parts of Europe, southern Africa, Australia, the Pacific Islands, and the eastern United States (Barker et al. 2005; Botha 2001; Botond and Zoltán 2004; Nakamura et al. 2012).

To date, no occurrence existed for this species in the Azores archipelago; the species appears to be expanding its range across São Miguel island, appearing mainly in roadsides, lawns, and highly disturbed natural areas (Figure 2).

This invasion alert reports the presence of *Y. japonica* in the Azores archipelago and aims to summarize the current knowledge of the natural history and invasion biology of this species.

Natural History, Taxonomy, and Distribution

Taxonomy

Youngia has a complex and puzzling taxonomy (Yahara 1995). However, studies from Nakamura et al. (2012, 2013) clarified its taxonomy and proposed the following. First, *Youngia japonica* subsp. *longiflora* should be considered a distinct lineage from *Y. japonica* and thus

Figure 1. *Youngia japonica* and details of its (A) leaves and (B) flower heads (capitula). (C) A population near Lagoa das Furnas, São Miguel Island, Azores.

treated as a separate species (i.e., *Youngia longiflora*). Moreover, three subspecies of *Youngia japonica* should be recognized (i.e., *Youngia japonica* subsp. *japonica*, *Youngia japonica* subsp. *formosana*, and *Youngia japonica* subsp. *monticola*). *Youngia japonica* subsp. *japonica* differs from the other two subspecies by having brown achenes that are less than 2-mm long. The inflorescence axes differentiate the other two subspecies. *Youngia japonica* subsp. *formosana* has densely pubescent inflorescence axes, at least at the base, while *Y. japonica* subsp. *monticola* inflorescence axes are glabrous or slightly puberulous at the base. The use of proper names for these ecologically and morphologically distinct subspecies is critical for genus nomenclature and biogeography, as well as invasiveness control activities (Nakamura et al. 2013). As a result, we conducted a detailed examination of Azorean plants that possessed achenes less than 2-mm long belonging to *Y. japonica* subsp. *japonica*.

Key to identifying similar genera occurring in the Azores:

1. Absence of pappus . . . . *Lapsana*
1. Presence of pappus 2
2. Achenes not compressed and 10-ribbed . . . . *Crepis*
2. Compressed, and unequally ribbed achenes . . . . *Youngia*

Key to identifying the different subspecies of *Y. japonica* (adapted from Nakamura et al. 2013):

1. Achenes brown, less than 2-mm long . . . . . *Youngia japonica* subsp. *japonica*
1. Achenes reddish brown to dark purplish brown, 2–2.5-mm long 2
2. Plants usually less than 25-cm tall with fewer than 20 heads per inflorescence axis; radical leaves lyrate-pinnatifid, velvety; inflorescence axes densely puberulous, at least at base . . . . . *Youngia japonica* subsp. *formosana*
2. Plants usually more than 25-cm tall with more than 20 heads per inflorescence axis; radical leaves runcinate-pinnatifid, glabrous or slightly puberulous; inflorescence axes glabrous or slightly puberulous at base . . . . . *Youngia japonica* subsp. *monticola*

https://doi.org/10.1017/inp.2023.32 Published online by Cambridge University Press

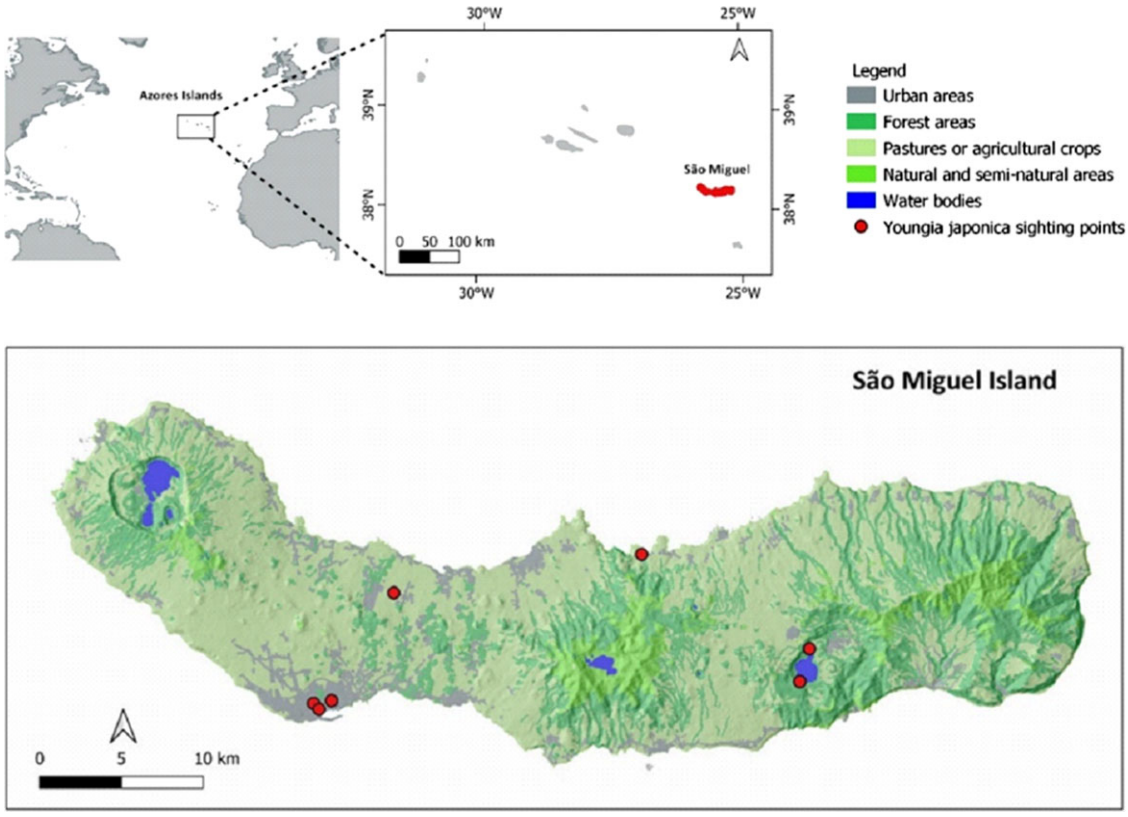

Figure 2. Distribution map with the red dots showing the sightings of *Youngia japonica* across São Miguel Island in the Azores archipelago.

Plant Traits

Youngia japonica is an annual or biennial species. According to the Flora of China Editorial Committee (2018), *Y. japonica* basal leaves are disposed as a rosette and are obovate to oblanceolate, pinnatipartite, or pinnatisect. The leaves and lower parts of the plant are variably pubescent, with weak, simple hairs scattered across the surface. The inflorescence forms a panicle or a corymbose cyme, with slender branches. The capitula are small and are composed of 10 to 20 florets, with phyllaries abaxially glabrous and adaxially appressed pubescent. The achene is light brown to dark reddish or purplish brown, ribbed, and fusiform with an attenuate apex. The pappus is white and has a single whorl of barbed hair.

Distribution Worldwide and in the Azores Archipelago

Youngia japonica is native to China, India, Japan, Korea, the Malay Peninsula, the Philippines, and Taiwan (Ling and Shih 1997). However, its nonnative range includes Africa, North and South America, Australia, Spain (Acevedo-Rodríguez and Strong 2007; Pagad et al. 2018; Pyke 2016); several Pacific islands (PIER 2016); and in the Macaronesia biogeographic region, Madeira (Jardim and Menezes de Sequeira 2021), Tenerife, and Gran Canaria (Verloove 2017). For the first time, we register the occurrence of *Y. japonica* in the Azores archipelago. This species has only been observed so far on the island of São Miguel (Figure 2), but it is already widely distributed on the island (Table 1).

Phenology

In its native range, *Y. japonica* flowering and fruiting periods vary depending on the region. In China, this taxon blooms and bears fruit from February to December (Flora of China Editorial Committee 2018), and in India, from October to April (India Biodiversity Portal 2018). In its nonnative area, this taxon has been seen to flower year-round (Davidse et al. 2018), a trait that has also been observed in the specimens from the island of São Miguel in the Azores archipelago.

Uses

Youngia japonica young leaves are consumed as a vegetable and used in traditional medicine. In terms of edibility, in its native range (i.e., China, India, Japan, Korea, the Malay Peninsula, the Philippines, and Taiwan), *Y. japonica* was consumed during times of famine, and nowadays is used in salads in North America (Ooi et al. 2004). It is used in folk medicine to treat colds and sore throats, as a diuretic to promote blood cleansing, and as an herbal treatment for diarrhea (Munira et al. 2018). It is used in external applications to treat boils, mastitis, shingles, and bruises (Ooi et al. 2004). Additionally, studies have shown that this species has anti-tumor activity and inhibitory potential against respiratory syncytial virus (Ooi et al. 2004), and it is a source of antioxidants (Kaur et al. 2019). *Youngia japonica* has also been shown to be a hyperaccumulator of cadmium (Yu et al. 2021), which may be useful for phytoremediation. Finally, it is used as an ornamental in various locations (Loewenstein and Loewenstein 2005).

Habitat

Youngia japonica is commonly found over a broad range of environmental conditions from coastal areas to mountain ranges and from forest margins to disturbed sites such as wastelands (Peng et al. 1998); in moist and semi-shaded habitats,

https://doi.org/10.1017/inp.2023.32 Published online by Cambridge University Press

Table 1. Observed *Youngia japonica* populations and their locations, altitudes, habitats, dates of observation, collectors' names, and herbarium voucher numbers when collected.

Location	Altitude m	Habitat	Date	Collector	Herbarium voucher
Portugal, Açores, São Miguel: Ponta Delgada, campus of the University of Azores	37	Urban, roadside	January 20, 2023	Roberto Resendes	AZB4573
Portugal, Açores, Porto Formoso, near Praia dos Moínhos	24	Urban, in a wall by the roadside	October 11, 2022	Guilherme Roxo	
Portugal, Açores, António Borges botanical garden	35	Urban, as a casual weed inside the garden	September 17, 2022	Guilherme Roxo	
Portugal, Açores, around Furnas Lake	291	Natural, forest of the invasive taxa *Pittosporum undulatum* Vent.	January 21, 2023	Guilherme Roxo	
Portugal, Açores, Ribeira Grande, Pico da Pedra	110	Urban, in a house lawn	January 27, 2023	Guilherme Roxo	

but it is also found in intact or minimally disturbed natural areas (Rojas-Sandoval 2020).

Dispersal

Youngia japonica is an autogamic species, exhibiting high seed set, even when pollination rates are low (Hauber et al. 1989). The seeds are readily dispersed by wind (Peng et al. 2018) and water (Kalaman and Marble 2023) and by contamination of soil, crop, and grass seeds (Drake 1998; Kalaman and Marble 2023). Moreover, *Y. japonica* seeds have been observed as a contaminant in seed lots of cultivated species (Hauber et al. 1989; USDA-NRCS 2018)

Invasive Significance

Plant invasions can result in adverse impacts on agriculture, the environment, and the economy. Weed-related crop yield losses are determined by a variety of factors, including weed emergence time, weed density, weed type, and crop, among others, and if not controlled, can result in a 100% yield loss (Chauhan 2020). Annually, in the United States, weeds cost US$33 billion in lost crop production (Pimentel et al. 2005). *Youngia japonica* is a weed of coffee (*Coffea arabica* L.), sugarcane (*Saccharum officinarum* L.), and wheat (*Triticum aestivum* L.) (Dangol 2013; Davidse et al. 2018; McIntyre 1991; Vibrans 2018). It may also inhibit the growth of coffee and alfalfa (*Medicago sativa* L.) through allelopathy (Chérigo et al. 2017; Yin et al. 2008), leading to yield and economic losses.

Environmentally, nonnative species are recognized as one of the major drivers of global biodiversity loss (Shabani et al. 2020). In fact, invasive species can have a detrimental impact on the ecosystems they invade, degrading ecosystem services and causing severe damage to economies and social livelihoods (Sudmeier-Rieux and Ash 2009). *Youngia japonica* invades both disturbed and undisturbed natural areas. Across the United States, this species has been described as "very common" and is spreading rapidly, invading intact or minimally disturbed forests, prairies, and coastal plains (Swearingen and Bargeron 2016). It grows well in response to human disturbance and is very common in areas such as roadsides, cultivated fields, lawns, pastures, and forest margins (Loewenstein and Loewenstein 2005; PIER 2016; Swearingen and Bargeron 2016; USDA-NRCS 2018; Weakley 2015). More importantly, it has been reported growing in Haleakala National Park in Hawaii, in nearly intact wet forests (Wagner et al. 1999). *Youngia japonica* was assessed by the Hawaii-Pacific Weed Risk Assessment (HPWRA) system as a high-risk species (score 14); thus, it is highly invasive in Hawaii and other tropical Pacific islands (HPWRA 2019). Moreover, it is mentioned on several lists of invasive species that support policy makers in the management of invasive species around the world (i.e., Invasive Species Compendium Datasheet and Database of Plants Invading Natural Areas in the United States, https://www.cabidigitallibrary.org/doi/10.1079/cabicompendium.117921).

Several activities, such as clearing native vegetation for cereal crops and the introduction of numerous crops and forage, forest, ornamental, and hedgerow plant species, have had a significant impact on native vegetation since human settlement in the Azores (Silva and Smith 2004). In addition to this, the recent intensification of pasture production and cattle grazing in the Azores has lead to eutrophication of soils (Pinheiro et al. 2007). In fact, a study conducted by Kurz et al. (2006) shed light on the shift in nutrient concentration caused by cattle and discovered an increase in particulate N, organic P, and K concentrations. Studies on plant invasions have provided evidence that invasive species abundance is positively correlated with proximity to disturbed areas (González-Moreno et al. 2015) and the amount of N in the soil (Nackley et al. 2017; Stohlgren et al. 1999). Based on the abovementioned research, the Azores provide an ideal habitat for invasive species such as *Y. japonica*.

It is unknown how and when this plant arrived in São Miguel, Azores. Species checklists attempt to reflect locations' species diversity. The most recent Azorean checklist was published in 2010 (Silva et al. 2010), and the online databases that are constantly updated, such as Portal da Biodiversidade dos Açores (2022) and eAZFlora (https://eazflora.org), do not have *Y. japonica* listed. Regarding its introduction pathway, according to the literature, a possible pathway is that it came as a contaminant in the seed lots of cultivated species (USDA-NRCS 2018). Based on its dominance on urban lawns and its presence in horticultural and agricultural fields, we hypothesize that *Y. japonica* was introduced recently as a contaminant in seed lots and that its occurrence in highly disturbed natural areas represents the start of an ongoing expansion that could reach intact forests, as the plant did in Hawaii.

No specific impacts of *Y. japonica* have been identified. However, given its propagation capacity, environmental versatility, allelopathic behavior, and recognized ecological risk by the HPWRA system, *Y. japonica* is a high-risk species for the Azores region, and monitoring must be undertaken in the vicinity of sites where it is known to occur (Figure 2). *Youngia japonica* control is even more crucial than ever. Recently, the Delta Cafés, the Azores Government, and the Association of Azorean Coffee Producers partnered in motivating growers to plant and produce

https://doi.org/10.1017/inp.2023.32 Published online by Cambridge University Press

coffee in the Azores. They provided financial support and encouragement to extant coffee producers for the expansion of their plantations and extended this support to new producers, promoting the cultivation of coffee in the Azores. This resulted in an unique and limited batch with 100% Azorean coffee that was commercialized by Delta Cafés (https://www.deltacafes.pt) and was referred to as "the impossible coffee," because Europe's climate did not provide the ideal conditions for the production of coffee.

Hence, the early detection of newly introduced species (particularly those with invasive behavior) is critical not only for minimizing potential damage to native populations and the ecosystem, but also, if *Y. japonica* colonizes coffee plantations, protecting the yield of the newest Azorean coffee, which is produced in small quantities. Therefore, because eradication is still feasible, we recommend the monitoring of and quick interventions for the rapidly spreading populations of *Y. japonica* in the Azores.

Control

When the plants are young, they can easily be pulled out. However, both above- and belowground plant parts must be removed. Mowing is ineffective, because this herbaceous plant will regrow quickly if root structures remain (USDA-NRCS 2018). It is critical for mechanical management of the plant to remove it before it matures and becomes deeply rooted. Moreover, the removal of plants should be performed before seed set, and care must be taken not to spread seeds to adjacent areas.

Mulching can help prevent any seeds in the soil from germinating or from falling into the soil. Natural mulches should be applied at least 5-cm (2-inches) deep to non-turf areas such as planting beds and foot paths for the best results (Unruh et al. 2020).

Chemical control is only recommended for highly invaded locations where mechanical control is no longer possible. According to Neal and Derr (2005), preemergence herbicides such as flumioxazin and tank mixes of oxyfluorfen and pendimethalin may control *Y. japonica*. Preemergence herbicides must be applied before weed emergence and incorporated after application to be effective. Most preemergence herbicides are generally effective for 6 to 12 wk and should be reapplied 6 to 9 wk later for optimum control (Unruh et al. 2020). Regarding postemergence treatment, pelargonic acid and broad-spectrum or nonselective herbicides such as glyphosate, glufosinate, and diquat are recommended (Kalaman and Marble 2023). However, caution should be exercised, because this species has shown resistance to herbicides such as diquat and paraquat (Hanoika 1987; Watanabe 1990).

Acknowledgments. The study was co-financed by FEDER (85%) and regional funds (15%), through the Azores 2020 Operational Programme, in the context of project eAZFlora (ACORES-01-0145-FEDER-000007). No competing interests have been declared.

References

Acevedo-Rodríguez P, Strong MT (2007) Catalogue of the Seed Plants of the West Indies. http://botany.si.edu/antilles/WestIndies/catalog.html. Accessed: February 27, 2023

Barker WR, Barker RM, Jessop JP, Vonow HP (2005) Census of South Australian Vascular Plants. 5th ed. (*Journal of the Adelaide Botanic Gardens*, Suppl. 1). Adelaide, Australia: Botanic Gardens of Adelaide and State Herbarium. 382 p

Botha C (2001) Common Weeds of Crops and Gardens in Southern Africa. Pretoria, South Africa: ARC-Grain Crops Institute. 384 p

Botond M, Zoltán BD (eds) (2004) Biologiai Invaziok Magyarorszagon: Ozonnovenyek [Biological Invasions in Hungary: Invasive Plants]. Budapest, Hungary: Természet BUVAR Alapítvány Kiadó. 366 p

Chauhan BS (2020) Grand challenges in weed management. Front Agron 1:3

Chérigo L, Lezcano J, Martínez-Luis S (2017) Diversity and allelopathic potential of weeds among Panamanian coffee crops. Online J Biol Sci 17: 232–239

Dangol DR (2013) Weeds of wheat in Nepal: a literature review. J Nat Hist Mus 17(27):132–178

Davidse G, Sousa-Sánchez M, Knapp S, Chiang F, UUoa Ulloa C, Pruski JF, eds (2018) Flora Mesoamericana. Volumen 5, Parte 2, Asteraceae. St Louis: Missouri Botanical Garden Press. 608 p

Drake DR (1998) Relationships among the seed rain, seed bank and vegetation of a Hawaiian forest. J Veg Sci 9:103–112

Flora of China Editorial Committee (2018) Flora of China. St Louis: Missouri Botanical Garden; Cambridge, MA: Harvard University Herbaria. http://www.efloras.org/flora_page.aspx?flora_id=2 Accessed: February 27, 2023

González-Moreno P, Diez JM, Richardson DM, Vilà M (2015) Beyond climate: disturbance niche shifts in invasive species. Glob Ecol Biogeogr 24:360–370

Hanoika YA (1987) Paraquat resistance in *Erigeron sumatrensis* Retz. and *Youngia japonica* DC. Weed Res (Japan) 32:137–140

Hauber DP, Kuhnell RJ, Miller MK (1989) Evidence for predominant autogamy in *Youngia japonica* (Asteraceae). Southwest Nat 34:557–559

[HPWRA] Hawaii-Pacific Weed Risk Assessment (2019) *Youngia japonica*. https://plantpono.org/. Accessed: May 22, 2023

India Biodiversity Portal (2018) Home page. http://indiabiodiversity.org/species/list. Accessed: May 22, 2023

Jardim R, Menezes de Sequeira M (2021) New taxa to the flora of Madeira archipelago islands (Portugal). Bot Complut 45:e78245

Kalaman H, Marble C (2023) Biology and Management of Asiatic False Hawksbeard (*Youngia japonica*) in Florida Ornamental Production and Landscapes. EDIS, 2023(4). https://journals.flvc.org/edis/article/view/132916

Kaur H, Puri R, Sharma ML, Khan S, Jhamta R (2019) Evaluation of antioxidant activity and GC-MS analysis of bioactive compounds present in leaf extract of *Youngia japonica* (L.) DC. from Chandigarh. Int J Life Sci Res 7:304–311

Kurz I, O'Reilly CD, Tunney H (2006) Impact of cattle on soil physical properties and nutrient concentrations in overland flow from pasture in Ireland. Agric Ecosyst Environ 113:378–390

Ling Y, Shih C (1997) Flora Reipublicae Popularis Sinicae. Volume 80. Beijing: Science Press. 500 p

Loewenstein NJ, Loewenstein EF (2005) Non-native plants in the understory of riparian forests across a land use gradient in the Southeast U.S. Pages 96–100 *in* Laband DN, ed. Emerging Issues along Urban/Rural Interfaces: Linking Science and Society. Auburn, GA: Auburn University

McIntyre G (1991) Weeds of Sugarcane in Mauritius: Their Description and Control. Rèduit, Mauritius: Mauritius Sugar Cane Research Institute. 151 p

Munira MS, Kabir MH, Bulbul IJ, Nesa ML, Muhit MA, Haque I (2018) Pharmacological activities of Youngia japonica extracts. Annu Res Rev Biol 25:1–14

Nackley L, Hough-Snee N, Kim S (2017) Competitive traits of the invasive grass *Arundo donax* are enhanced by carbon dioxide and nitrogen enrichment. Weed Res 57:67–71

Nakamura K, Chung KF, Huang CJ, Kono Y, Kokubugata G, Peng CI (2012) Extreme habitats that emerged in the Pleistocene triggered divergence of weedy *Youngia* (Asteraceae) in Taiwan. Mol Phylogenet Evol 63:486–499

Nakamura K, Kono Y, Huang C Jr, Chung KF, Peng CI (2013) Correction of confusions regarding the identity and synonymy of *Youngia* (Asteraceae: Tribe *Cichorieae*) in Taiwan. Syst Bot 38:507–516

Neal JC, Derr JF (2005) Weeds of Container Nurseries in the United States. Raleigh: NorthCarolia Association of Nurserymen. http://content.ces.ncsu.edu/static/publication/js/pdf_js/web/viewer.html?slug=weeds-of-container-nurseries-in-the-us

Ooi LS., Wang H, Luk CW, Ooi VE (2004) Anticancer and antiviral activities of *Youngia japonica* (L.) DC (Asteraceae, Compositae). J Ethnopharmacol 94:117–122

Pagad S, Genovesi P, Carnevali L, Schigel D, McGeoch MA (2018) Introducing the Global Register of Introduced and Invasive Species. Sci Data 5:1–12

Peng CI, Chung KF, Li HL (1998) Compositae. Pages 807–1101 *in* Editorial Committee of the Flora of Taiwan, eds. Flora of Taiwan. Volume 4. 2nd ed. Taipei: Editorial Committee of the Flora of Taiwan

Peng X, Pan Y, Zhu X, Zhou X, Gao J, Wang C (2018) Morphological characters and wind dispersal property of pappose seeds for seven common Compositae weeds in Yunnan, China. J Yunnan Univ Nat Sci 40:1024–1033

Pimentel D, Zuniga R, Morrison D (2005). Update on the environmental and economic costs associated with alien-invasive species in the United States. Ecol Econ 52:273–288

Pinheiro J, Matos L, Simões V, Madruga J (2007) Eutrophication in the Azores Islands. Pages 611–621 *in* Arnalds Ó, Óskarsson H, Bartoli F, Buurman P, Stoops G, García-Rodeja E, eds. Soils of Volcanic Regions in Europe. Berlin: Springer

[PIER] Pacific Islands Ecosystems at Risk (2016) Plant threats to Pacific ecosystems. HEAR, University of Hawaii. http://www.hear.org/pier/

[POWO] Plants of the World Online (2023) Home page. Facilitated by the Royal Botanic Gardens, Kew. http://www.plantsoftheworldonline.org. Accessed: February 27, 2023

Portal da Biodiversidade dos Açores (2023) Portal da Biodiversidade dos Açores. https://azoresbioportal.uac.pt. Accessed October 9, 2023

Pyke S (2016) *Youngia japonica* (L.) DC. (Compositae), recently detected in Barcelona. Collect Bot 35:e005–e005

Rojas-Sandoval J (2020) *Youngia japonica* (oriental false hawksbeard). Invasive Species Compendium CABI. https://doi.org/10.1079/cabicompendium.117921. Accessed: May 24, 2023

Shabani F, Ahmadi M, Kumar L, Solhjouy-fard S, Tehrany MS, Shabani F, Kalantar B, Esmaeili A (2020) Invasive weed species' threats to global biodiversity: future scenarios of changes in the number of invasive species in a changing climate. Ecol Indic 116:106436

Shi Z, Kilian N (2011) *Youngia* Cassini. Pages 252–263 *in* Wu ZY, Raven PH, Hong DY, eds. Flora of China. Volumes 20–21. Beijing: Science Press; St Louis: Missouri Botanical Garden Press

Silva L, Moura M, Schaefer H, Rumsey F, Dias EF (2010) List of vascular plants (Tracheobionta). Pages 117–146 *in* Borges PAV, Costa A, Cunha R, Gabriel R, Gonçalves V, Martins AF, Melo I, Parente M, Raposeiro P, Rodrigues P, Santos RS, Silva L, Vieira P, Vieira V, eds. A List of the Terrestrial and Marine Biota from the Azores. Cascais, Portugal: Princípia

Silva L, Smith CW (2004) A characterization of the non-indigenous flora of the Azores Archipelago. Biol Invasions 6:193–204

Slanis AC, Perea MC (2011) *Youngia japonica* (Asteraceae, Lactuceae), una novedad para la flora adventicia de Argentina. Bol Soc Argent Bot 46: 139–143

Stohlgren TJ, Binkley D, Chong GW, Kalkhan MA, Schell LD, Bull KA, Otsuki O, Newman G, Bashkin M, Son Y (1999) Exotic plant species invade hot spots of native plant diversity. Ecol Monogr 69:25–46

Sudmeier-Rieux K, Ash N (2009) Environmental Guidance Note for Disaster Risk Reduction: Healthy Ecosystems for Human Security. Gland, Switzerland: IUCN. 40 p

Swearingen J, Bargeron C (2016) Invasive Plant Atlas of the United States. University of Georgia Center for Invasive Species and Ecosystem Health. http://www.invasiveplantatlas.org. Accessed: May 24, 2023

Unruh JB, Trenholm L, Harlow E, Leon RG (2020) Weed Management Guide for Florida Lawns. ENH884/EP141, rev. 9/2020. EDIS, 2020(5)

[USDA-NRCS] U.S. Department of Agriculture–Natural Resources Conservation Service (2018) The PLANTS Database. Greensboro, NC: National Plant Data Team. https://plants.sc.egov.usda.gov. Accessed: May 24, 2023

Verloove F (2017) New xenophytes from the Canary Islands (Gran Canaria and Tenerife; Spain). Acta Bot Croat 76:120–131

Vibrans H (2018) Weeds of Mexico. (Malezas de México.) In: Malezas de México. http://www.conabio.gob.mx/malezasdemexico/2inicio/home-malezas-mexico.htm. Accessed: November 27, 2023

Wagner WL, Herbst DR, Sohmer SH (1999) Manual of the Flowering Plants of Hawaii. Rev ed. Bernice P. Bishop Museum Special Publication. Honolulu, HI: University of Hawai'i Press/Bishop Museum Press. 1919 p

Watanabe Y (1990) Discovery, development and distribution of paraquat-resistant biotype weeds in Japan. Korean J Weed Sci 10:163–170

Weakley AS (2015) Flora of the Southern And Mid-Atlantic States. Chapel Hill: University of North Carolina Herbarium, North Carolina Botanical Garden. http://www.herbarium.unc.edu/flora.htm. Accessed: February 27, 2023

Yahara T (1995) Ixeris cass. Pages 15–19 in vol. 3b, Iwatsuki K, Yamazaki T, Boufford DE, Ohba H, eds. Flora of Japan. Tokyo: Kodansha

Yin YL, Li HX, Wang J, Zhang DS, Yu YX, Qi ZQ (2008) The allelopathy of 3 companion weeds with alfalfa. Grass Sci 12:131–135

Yu B, Peng Y, Xu J, Qin D, Gao T, Zhu H, Zuo S, Song H, Dong J (2021) Phytoremediation potential of *Youngia japonica* (L.) DC: a newly discovered cadmium hyperaccumulator. Environ Sci Pollut Res 28: 6044–6057

https://doi.org/10.1017/inp.2023.32 Published online by Cambridge University Press