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Original Article

Invasion dynamics and seasonal development of *Youngia japonica* in Western Georgia (Colchis lowland)

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Abstract

Youngia japonica (L.) DC. is an East Asian alien plant species that has recently established populations in Western Georgia, particularly within the Colchis lowland. This study examines its biomorphological traits, phenological rhythm, and ecological adaptability in newly colonized habitats. Field investigations conducted between 2016 and 2025 revealed that *Y. japonica* completes its full life cycle in Western Georgia (Colchis lowland), with germination typically beginning in late summer, flowering occurring in spring, and the vegetation phase concluding by mid-summer. Despite a shorter flowering and fruiting period compared to its native range, the species produces viable seeds and demonstrates strong ecological plasticity. It thrives in diverse habitats, including agroecosystems, ruderal areas, and disturbed urban substrates, and regenerates effectively after mechanical disturbance. A comparative analysis with other regions confirms its high invasive potential and adaptability. The study underscores the importance of phenological monitoring and early detection for managing the species' spread in Georgia (Colchis lowland).

Keywords: Alien species, Colchis lowland, Ecological plasticity, Invasive plants, Phenology, Seasonal development, *Youngia japonica*

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Introduction

The spread of alien plant species in Georgia dates back to ancient times. Particularly noteworthy is Western Georgia, especially the Colchis lowland, where numerous alien species have become so well-established and naturalized that they flower, bear fruit, reproduce by self-seeding, expand, and broaden their distribution range.
The invasion and spread of alien species continue to this day. Of particular interest is the East Asian plant *Youngia japonica* (L.) DC., whose first specimens appeared in the Colchis lowland in 2015 (Mikeladze, 2022; Mikeladze et al., 2021). The spring of 2021 marked the peak of its spread, both in agrocenoses and in secondary and semi-natural ecosystems.
Various studies have established a connection between the rhythm of plant development and their geographical origin. The growth and developmental peculiarities of plants depend, on the one hand, on inherited traits and on the other, on the complex influence of environmental conditions (Gulisashvili, 1969; Nakhutsrishvili, 1971; Nakhutsrishvili, 1981; Lodkina, 1983; Sattler and Rutishauzer, 1997; Davitadze, 2002). Environmental factors affect the viability of aliens and introduce plant species in various ways. Moreover, the relationship between environmental factors and plants is a complex and dynamic process. It is influenced by meridian and latitudinal positions, altitude above sea level, as well as soil-climatic and other ecophysiological characteristics. In a new environment, climatic conditions can significantly alter the rhythm of plant growth and development (Klebs, 1911; Serebryakov, 1965; Tatishvili, 1967; Tsitsvidze, 1973; Mikhalevskaya, 2002).
Considering the above, it is essential to study the biomorphological characteristics, seasonal development rhythm, vegetation period, flowering, and other traits of *Y. japonica* in new soil-climatic conditions.
Y. japonica (L.) DC. is considered a pantropical weed, most likely originating in China and currently widespread across tropical and subtropical regions (Shi and Kilian, 2011). Currently, *Y. japonica* is considered a species native to temperate and tropical Asia, as well as Australia. It has been introduced to Africa, the Canary Islands, North and South America, the Caribbean, many Pacific islands, and Europe. The genus comprises 30–40 species, primarily distributed across Asia (Spurr, 2011; Verloove and Gullón, 2012; Pyke, 2017; Verloove, 2017; Atha, 2019).
Within its native range, *Y. japonica* occupies a wide variety of habitats: it is found on mountain slopes, valleys, ravines, forest edges, meadows, streambanks, trails, roadsides, borders, and open or disturbed-degraded areas from 100 to 4500 meters above sea level. It also occurs in gardens and lawns, field edges, pastures, cultivated crop plantations (e.g., coffee), and grassy areas near residences.

Material and Methods

The subject of this study is the alien species *Youngia japonica* (L.) DC., currently establishing populations across the humid subtropical ecosystems of Western Georgia (Colchis lowland). Traditional botanical expeditions and field surveys were conducted between 2016 and 2025 (Figure 1). Primary data were gathered via bi-weekly monitoring across diverse ecotopes, categorized into: (1) agroecosystems (citrus and hazelnut plantations), (2) ruderal areas (roadsides, pavement cracks, concrete walls), and (3) disturbed semi-natural habitats (forest edges, riverbanks). Seasonal growth, biomorphological traits, and phenological rhythms were evaluated following standardized protocols (Davitadze, 2002; Haggerty and Mazer, 2008). Specifically, life-cycle transitions (autumn germination, wintergreen vegetative survival, spring bolting, mass flowering, and seed maturation) and morphometric parameters (plant height and root architecture) were documented. Additionally, qualitative resilience and vegetative regeneration efficiency were assessed following mechanical disturbances. Local reproductive duration was comparatively analyzed against global floristic literature to evaluate the species' phenological plasticity.

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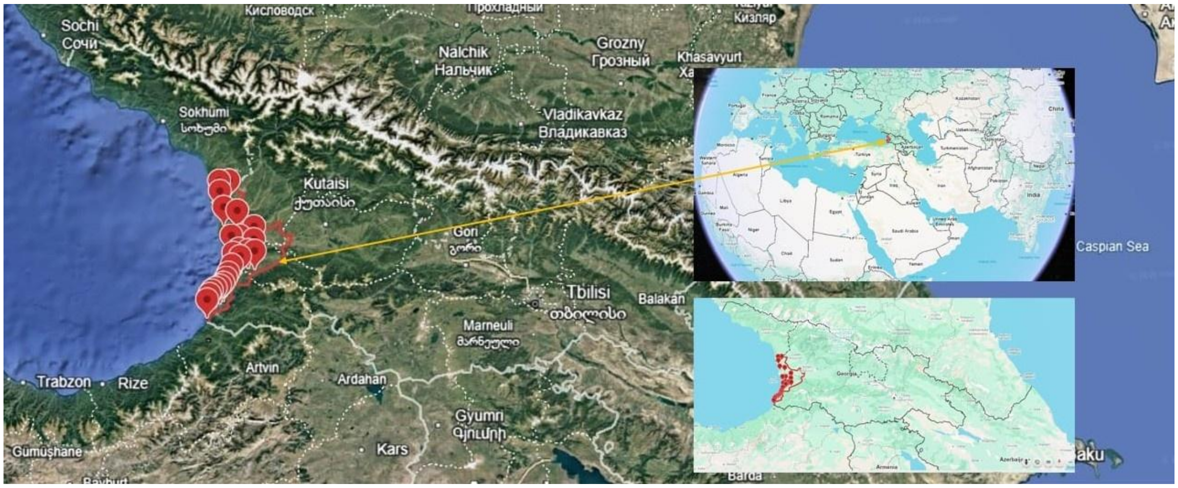

Figure-1. Map of the research area.

Botanical description and distribution aspects

Youngia japonica (L.) DC., Prodr. [A.P. de Candolle] 7(1):194 (1838). Synonyms: *Prenanthes japonica* L., Mant. Pl. 107 (1767); *Crepis japonica* (L.) Benth., in Fl. Hongk.: 194 (1861).

Y. japonica belongs to the family *Asteraceae* Bercht. & J. Presl., and the genus *Youngia* Cass. It is an annual or biennial herbaceous plant of East Asian origin. The stem may be solitary or multiple, erect, branched, smooth, or more frequently pubescent, and may be leafy or leafless. Rosette leaves are more or less oblanceolate or lyrate, lobed or pinnatifid, occasionally entire, glossy or partially pubescent. The terminal portion may be long or short, narrowly winged or wingless, with serrated or undulate margins. Cauline leaves resemble the rosette leaves but gradually decrease in size toward the top of the stem. Inflorescences are corymbose or paniculiform-corymbose, often with numerous capitula. Each capitulum contains 1-12 florets (Figure 2).

Figure-2. Flowering plant and capitula of *Youngia japonica.*

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Results

The first specimens of *Youngia japonica* (L.) DC. were recorded by us in 2015 within the floristic region of Adjara (Georgia). Since then, further identification work and observations were conducted, focusing on the species' reproduction, distribution, and growth-developmental features. The spring of 2021 marked the peak of *Y. japonica's* spread across the floristic regions of Adjara and Guria, particularly along the coastal plains, hills, and foothill areas-both in agrocenoses and in secondary or semi-natural communities. The species was found in citrus and hazelnut plantations, roadsides, streets, sidewalk cracks, trail sides, in paving stones, ruderal areas, and forest edges.

The duration and seasonality of leaf surface function-i.e., the longevity of assimilation organs-indicate the level of the plant's adaptation to specific climatic conditions. Our observations show that based on leafing patterns and the longevity of shoots and leaves, *Y. japonica* belongs to the phenological group of wintergreen plants, with germination starting in late August or September.

Favorable climatic conditions during autumn facilitate the development of both the root system and photosynthetic surface (leaves) of *Y. japonica* (both above and belowground parts) (Figure 3).

Figure-3. Root system and leaves of *Youngia japonica* seedlings.

Cold winter months (December-January) slow down the plant's growth to some extent, but active vegetation resumes by late February. In early spring, new leaves begin to form, reaching maximum assimilation surface area by March. Additional rosette leaves also develop during this time. In April, flowering shoots begin to emerge (Figure 4, Table 1).

https://doi.org/10.35495/ajab.2026.090

Figure-4. Initiation of flowering shoot development in *Youngia japonica.*

Table-1. Seasonal development spectrum of *Youngia japonica.*

Vegetation \ Months	VIII	IX	X	XI	XII	I	II	III	IV	V	VI	VII
Germinate												
Leaf formation												
Blooming and fruit formation												
End of vegetation-leaf fall												

Flowering in plants is influenced by a combination of endogenous and exogenous factors. Based on the timing and duration of flowering, *Y. japonica* belongs to the spring-summer flowering group. In April, flowering shoots develop; by the second half of April, budding and initial flowering begin. Mass flowering and seed maturation/dispersal occur in May. By mid-June, mass flowering concludes. During this time, some individuals reach 70-80 cm in height, although flowering individuals can also be found at 20-30 cm or slightly taller. The flowering period lasts 50-60 days. A few smaller specimens continue flowering until the end of July. Vegetation ends in July, and by August, leaves wither, and the life cycle is complete. Leaves remain functional for 9-10 months.

Based on rhythmic-morphological characteristics, the life form of *Y. japonica* can be classified as an annual monocarpic autumn-germinating overwintering species. As noted earlier, germination typically begins in autumn and continues for 1-1.5 months. Flowering occurs in spring and summer. Vegetation ends in July, and the life cycle is completed within approximately 10 months.

Y. japonica produces a large quantity of seeds, which are easily dispersed by wind, water, and rivers. The species exhibits high ecological plasticity, enabling it to adapt to various ecotopes. It also demonstrates strong regenerative capabilities after mowing or hoeing, which contributes to its establishment in agricultural fields, citrus plantations, abandoned lots, riversides, canals, and ruderal areas. Furthermore, *Y. japonica* readily colonizes cracks in concrete, asphalt, and pavements, and can establish at the base of retaining walls, habitats in which most other plant species are unable to persist.

Discussion

The seasonal rhythm of plant development and shoot formation in *Youngia japonica* is closely linked to its life-form strategy, which reflects long-term evolutionary adaptation to environmental conditions. Life forms represent an integrated expression of hereditary traits, ecological history, and adaptive responses, ultimately determining species performance across different climatic regions (Nakhutsrishvili, 1981; Davitadze, 2002; Mikhalevskaya, 2002; Cleland et al., 2012;). In this context, the successful establishment of *Y. japonica* in Western Georgia (Colchis lowland) indicates a high degree of phenotypic plasticity, enabling the species to adjust its developmental timing under novel environmental conditions.

A key finding of this study is the pronounced compression of the phenological cycle of *Y. japonica* in the Western Georgia (Colchis lowland) compared to both its native and other introduced ranges (Figure 5). According to available data, in its native range (e.g., China), the flowering and fruiting period of *Y. japonica* spans up to 10 months from February to December (Shi and Kilian, 2011). In non-native regions, these periods are generally shorter. For example, in India, flowering and fruiting extend over seven months, from October to April (Dashrath and Madhukar, 2009). In the United States, it flowers and fruits from March to July (five months), although in southern states, it may flower year-round (Spurr, 2011). In Indonesia, flowering and fruiting occur from March to July-August. In Georgia, this period is reduced to approximately 3-4 months.

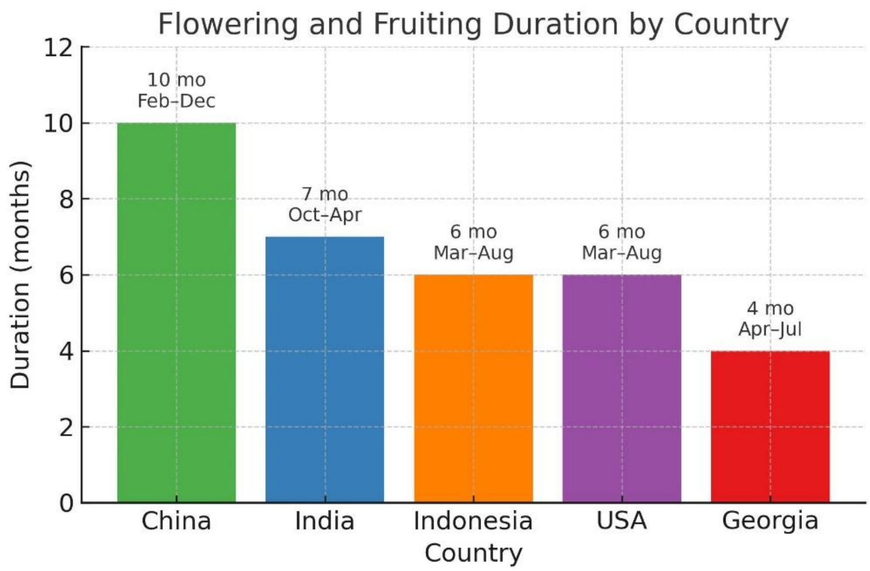

Figure-5. Flowering and fruiting periods and their duration in *Youngia japonica* across different regions of the world.

This phenological shortening likely reflects constraints imposed by regional climatic conditions, particularly the interaction of temperature regimes, high atmospheric humidity, and seasonal precipitation patterns characteristic of the humid subtropical climate of the Colchis lowland.
This compression of reproductive timing can be interpreted as an adaptive response that allows *Y. japonica* to synchronize its life cycle with the most favorable environmental conditions. In this region, late summer and autumn conditions promote germination and vegetative development, while relatively mild winters allow overwintering in a vegetative state. Rapid transition to reproductive phases in spring ensures seed production before the onset of summer stress factors, including increased competition, localized soil drying, and anthropogenic disturbance. Such temporal adjustment is a common strategy among invasive annuals and is considered a key component of invasion success.
Despite the shortened reproductive phase, *Y. japonica* maintains high reproductive efficiency, producing a

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large number of viable seeds and ensuring effective dispersal via wind and water. This indicates that phenological compression does not reduce fitness, rather enhances it by optimizing resource allocation within a limited time frame. These characteristics are consistent with those of ruderal (r-selected) species, which prioritize rapid growth, early reproduction, and high propagule output in unstable or disturbed environments. The observed traits of *Y. japonica* in the Colchis lowland align with Baker's (1965) concept of the "ideal weed", particularly regarding its plastic phenological response and the ability to maintain high reproductive output under suboptimal edaphic conditions.

The broad ecological amplitude observed in *Y. japonica* across the Western Georgia (Colchis lowland) further supports its classification as a highly plastic and opportunistic species. As highlighted by Richards et al. (2006), phenotypic plasticity is often a defining trait of successful invaders, allowing them to maintain high performance across a range of environmental conditions. Literature data indicate that the species typically occurs on moist, well-drained soils with a pH range of approximately 6.0-8.0. However, in the Colchis lowland, where soils are predominantly acidic, *Y. japonica* nevertheless develops successfully and forms stable populations. This suggests that its edaphic tolerance is broader than previously reported and that the species is capable of maintaining physiological performance under more acidic soil conditions (Shi and Kilian, 2011; Spurr, 2011; Urushadze, 2015).

Such tolerance to suboptimal or variable soil chemistry, combined with its ability to colonize disturbed habitats, reduces interspecific competition and facilitates establishment in a wide range of ecological niches. The frequent occurrence of *Y. japonica* in extreme microhabitats, such as cracks in asphalt, concrete substrates, and compacted urban soils, further highlights its resistance to substrate limitations, mechanical disturbance, and altered hydrological regimes.

From a biogeographical perspective, the variation in phenological patterns across regions suggests that *Y. japonica* exhibits flexible niche occupation rather than strict niche conservatism. This ability to synchronize its development with local environmental cues is consistent with the findings of Cleland et al. (2012), who demonstrated that phenological tracking is a critical mechanism for species to maintain fitness under shifting climatic conditions. The shift toward a shorter but efficient life cycle in Western Georgia (Colchis lowland) reflects rapid adjustment to local climatic and edaphic constraints, supporting the hypothesis that phenological plasticity and broad environmental tolerance are key drivers of its global spread.

Importantly, the completion of a full life cycle under local conditions confirms that *Y. japonica* has reached the stage of naturalization, while its continued expansion indicates ongoing progression toward invasiveness. Long-term observations (2016-2025) demonstrate that interannual climatic variability does not significantly limit its reproductive success, underscoring the stability of its adaptive strategy.

From a management perspective, the identified phenological pattern has direct practical implications. The concentration of flowering and seed production within a relatively short spring-early summer period creates a narrow but critical window for control measures. This rapid development reflects a 'phenological escape' strategy (Godoy et al., 2009), allowing the species to complete its reproductive cycle before the onset of summer stressors. Mechanical removal or disturbance prior to peak seed set (May-June) may significantly reduce population expansion, whereas delayed interventions are likely to be less effective due to rapid seed dispersal and high regenerative capacity.

Overall, the invasion dynamics of *Y. japonica* in Western Georgia (Colchis lowland) illustrate how phenological flexibility, rapid life-cycle completion, high reproductive output, and broad edaphic tolerance interact to facilitate successful establishment and spread in newly colonized regions. These findings emphasize the importance of integrating phenological monitoring and habitat-specific factors into early detection and management strategies for alien plant species in the Western Georgia (Colchis lowland) and similar ecosystems.

Conclusion

Study of *Youngia japonica* (L.) DC. in the Colchis lowland of Georgia reveals a high degree of ecological plasticity and adaptive capacity in a newly introduced alien species. Field observations conducted between 2016 and 2025 show that the species has completed its full life cycle in Georgia, despite a relatively short flowering and fruiting period compared to other regions. This ability to develop viable seeds and sustain self-propagating populations confirms its

naturalization and ongoing expansion within the region.
The species demonstrates a distinct seasonal rhythm: germination typically begins in late summer to early autumn, followed by overwintering in the vegetative state, spring flowering, and completion of the life cycle by mid-summer. *Y. japonica* can flower and fruit even under challenging edaphic and climatic conditions, such as disturbed urban substrates, agricultural plantations, and ruderal habitats. These traits underscore its classification as a wintergreen, spring-summer flowering, annual monocarpic, autumn-germinating overwintering species.
Comparative analysis of phenological data from its native and non-native ranges (China, India, USA, Indonesia) highlights the species' responsiveness to local climatic regimes. While its reproductive period is shorter in Georgia, *Y. japonica* maintains high seed productivity, effective dispersal mechanisms, and the ability to regenerate after disturbance. These characteristics significantly contribute to its invasive potential.
The findings of this study not only document the successful establishment of *Y. japonica* in Georgia but also emphasize the importance of monitoring its phenological phases and ecological behavior. This knowledge provides a basis for assessing invasion risk and implementing effective management strategies. As the species continues to spread in both natural and anthropogenic environments, early detection and control will be critical to limiting its ecological impact.

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Use of Generative AI Tools Statement
Generative AI tools were not employed in the experimental design, data collection or analysis of this study. Their use was limited solely to improving the linguistic clarity and grammatical accuracy of the manuscript.

Contribution of Authors
Mikeladze I & Baratashvili D: Conceptualization, study design, supervision and methodology.
Mikeladze I, Bolkvadze G, Bakuridze M & Zoidze L: Field data collection, sampling and visualization.
Bakuridze M & Zoidze L: Manuscript writing - original draft.

All authors read and approved the final draft of the manuscript.

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