

Research Article

Distribution and invasiveness of some invasive alien species (IAS) of plants in ecosystems of Colchis lowland (W Georgia / Sakartvelo)

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Abstract

The article presents the results of a floristic and phytosociological study conducted in western Georgia, specifically in the Colchis lowland, from 2021 to 2023. Thirty alien plant species, which have invaded at different times and are currently widely distributed, were identified based on botanical expeditions, field studies, and laboratory analyses of collected materials.

Among the widespread species, six alien plants were identified: Canadian goldenrod (*Solidago canadensis* L.), honey locust (*Gleditsia triacanthos* L.), false indigo (*Amorpha fruticosa* L.), common ragweed (*Ambrosia artemisiifolia* L.), Brazilian vervain (*Verbena brasiliensis* Vell.), and bur cucumber (*Sicyos angulatus* L.). To study the characteristics of their distribution, research was conducted using Braun-Blanquet quadrat methods within the administrative boundaries of Kolkheti National Park and in the Chorokhi Delta along marked transects. As a result, the frequency, coverage, and density of their distribution were determined. The characteristics of their occurrence in ecosystems and their invasive potential were also assessed.

Key words: Alien plant, Colchis lowland, cover-abundance, ecological assessment, invasive alien species (IAS), widely distributed species



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Introduction

In the initial stages of their introduction into non-native environments, alien species primarily spread along roadsides, ruderal areas, forest edges, and secondary cenoses disturbed by human activity. Over time, they begin to proliferate in large numbers, spread into natural cenoses, take a dominant position, and alter the species composition and structure of landscapes and phytocenoses.

In addition to natural coenoses, alien species also spread into agrocoenoses, impacting crop yields and causing ecological, economic, and human health problems. These species often appear as invasive and weedy, making their study a major challenge for modern ecological research (Richardson et al. 2000; Pimentel 2005; Pimentel et al. 2005; Gurevitch et al. 2011; Pyšek et al. 2012; Mikeladze 2015; Simberloff 2013; Thalmann et al. 2015; Mikeladze et al. 2023).

Colchis, which is the historical name of western Georgia and also represents a botanical geographical unit, has always been of great interest due to its location, natural conditions, resources, and biodiversity. Colchis has been a subject of special interest throughout the entire historical period. It was here that the ancient Argonauts landed in search of the Golden Fleece in the 2nd millennium BC. The lush vegetation of Colchis, vividly and colorfully described in Homer's "Iliad", has always aroused great interest among both conquerors and naturalist researchers (Chitanava 2004).

The first known physical–geographical references, which, among other things, describe the vegetation of Colchis, date back to the 6th century BC and are associated with Greek writers who visited the region before our era: Scylax, Herodotus, Xenophon, and Strabo. The ancient Roman writer and scientist Pliny the Elder (1st century AD) described the nature of Colchis in his work "Geographical Guide". Various geographical and natural descriptions are found in the works of the Alexandrian naturalists Claudius Ptolemy (1st century AD), Flavius Arion (11th century AD), and Stephanus of Byzantium (5th century AD).

The book "Description of Colchis" by the Italian missionary Arcangelo Lambert, dated 1654, contains information about the natural elements of this region and plays an important role in understanding the nature of Colchis.

Vakhushti Bagrationi describes Colchis in great detail, including its mountains, valleys, rivers, lakes, mineral wealth, vegetation (both wild and cultivated), and fauna of the time. It is particularly valuable that he was the first to notice, as early as the 17th century, changes in the elements of the geographical landscape in relation to altitudinal zoning. Without scientific justification, he differentiated the nature of valleys and high mountains.

Botanical studies of Colchis were initiated by J. Tournefort, who visited the Pontic Mountains in 1701. Since then, the vegetation of Colchis has been studied by various scientists: Derville (1819–1820), Nordmann (1835), Koch (1843), Pavillon (1853), Kotchy (1859), Ruprecht (1861), Medvedev (1869, 1883), Balan (1866), Trautvetter (1886), Sommier and Levier (1890), Krasnov (1891), Albov (1888, 1889–1893), Bush (1900), Anderson (1910), Rikli and Engler (1913), Palibin (1920, 1929), Shishkin (1930), Boxberger (1934), and Kolakovskiy (1933–1997). Notable works also include those by Dolukhanov, Takhtajian, Sakhokia, Yaroshenko, Ratiani, Makashvili, Maleev, Sosnovsky, Dmitrieva, Sokolov, Gagnidze, Kharadze, Sokhadze, Ketskhoveli, Kutateladze, Kemularia-Natadze, Gulisashvili, and others (Chitanava 2004).

Scientists of the Batumi and Sukhumi Botanical Gardens of the Georgian Academy of Sciences have played a significant role in the study of the flora of Georgia and, with it, the flora of Colchis. The flora of Colchis was also studied within the framework of separate regional floristic studies, including the "Flora of Abkhazeti" (Kolakovskiy 1980, 1982, 1985, 1986), the "Identification guide to plants of Adjara" (Dmitrieva 1990), and the "Flora of Georgia" (1971–2015).

The first list of the flora of Colchis was compiled by Albov, which included 1500 species (Albov 1895, 1896). Six decades later, based on research carried out by botanists in different parts of Colchis, as well as their own descriptions, records of new species, and analysis of materials, Kolakovskiy indicated 2000 species for the flora of Colchis (Kolakovskiy 1961). According to the latest data, the flora of Colchis includes 3596 species of higher plants, which comprise both naturalized and adventive species (Chitanava 2004, 2007).

A unified list of non-native alien organisms has not yet been compiled for Georgia. According to a work published in 2010, which is mainly based on literary sources, there are about 450 alien plants in Georgia (Kikodze et al. 2010). When studying the flora of individual regions of Georgia or the country in general, adventive, introduced, and naturalized species of foreign origin were also recorded. Plants of foreign origin widespread in Colchis were also studied within the scope of the description of the local flora. In Kolakovsky's (1961) work we read that "based on long-term economic use, the floristic region of Colchis has also been enriched with many (approximately 600) introduced species." Chitanava (2007), in describing the local flora of Colchis, separately identifies 349 adventive species.

Data on individual floristic regions, valleys, and species of the Colchis botanical–geographical unit can be found in various publications. Among these, the most notable are the "Advent flora of Abkhazeti", which includes 376 species (Yabrova-Kolakovskaya 1977), and the "Advent flora of Adjara", which includes up to 430 species (Davitadze 2001). According to recent data, the number of species of foreign origin in the Adjara floristic region is up to 500 (Mikeladze 2022). Important studies have been conducted by various scientists (Voronov 1916; Grossheim and Makashvili 1929; Kolakovsky and Sakhokia 1946; Manjavidze and Matinyan 1964; Dmitrieva 1967; Memiadze 1971; Davitadze 1981; Davitadze et al. 2009; Buachidze and Tkebuchava 2012; Mikeladze et al. 2012; Mikeladze et al. 2014; Lakushenko et al. 2016; Matchutadze et al. 2016; Mikeladze et al. 2016; Slodowicz et al. 2018; Mikeladze et al. 2019; Mikeladze and Sharabidze 2020; Mikeladze et al. 2021; Mikeladze et al. 2023).

The appearance of alien species in Colchis is associated with the introduction of cultivated plants. For example, the introduction of rice cultivation is associated with the spread of the following alien invasive species: sweet flag (*Acorus calamus*), wavyleaf basketgrass (*Oplismenus undulatifolius*), Indian goosegrass (*Eleusine indica*), small-flower umbrella sedge (*Cyperus difformis*), and others. They have become so established in the local vegetation that it is sometimes difficult to distinguish them from local species. Some alien, invasive, adventive, and weedy species are companions of particular crops, while others are associated with the development of other types of agriculture and farming. It is worth noting the period (early 20th century) when the local forests of Colchis were gradually replaced by plantations of subtropical crops—tea, citrus, bamboo, and tung—and alien species spread accordingly. The spread of many alien species is also associated with the introduction of potatoes, corn, tomatoes, and East Asian subtropical plants.

The invasion and establishment of alien species in agro- and natural coenoses continue today, with the anthropogenic factor playing a major role in this process. Humans are involved in these processes, either willingly or unwillingly. For example, plant propagation can occur through seeds of cultivated plants, fodder, seedlings, building materials, and more (Ketskhoveli 1959; Kolakovsky 1961; Davitadze 2001, 2002).

The flora of Colchis contains many alien species that have become so established and widespread in agro- and natural coenoses that they are difficult to distinguish from the aboriginal flora. These include: common ragweed (*Ambrosia artemisiifolia*), false indigo (*Amorpha fruticosa*), sticktight (*Bidens*), amaranth species (*Amaranthus*), broomsedge bluestem (*Andropogon virginicus*),

jimson weed (*Datura stramonium*), spurge (*Euphorbia*), galinsoga (*Galinsoga*), pennywort (*Hydrocotyle*), Japanese honeysuckle (*Lonicera japonica*), burclover (*Medicago*), Japanese stiltgrass (*Microstegium*), wood sorrel species (*Oxalis*), paspalum (*Paspalum*), pokeweed (*Phytolacca americana*), knotweed (*Polygonum/Persicaria*), kudzu (*Pueraria lobata*), thistle (*Cirsium*), black locust (*Robinia pseudoacacia*), foxtail millet (*Setaria*), nightshade species (*Solanum*), Asiatic dayflower (*Commelina communis*), Canadian goldenrod (*Solidago canadensis*), johnsongrass (*Sorghum halepense*), clover species (*Trifolium*), vetch (*Vicia*), spiny cocklebur (*Xanthium spinosum*), Chinese silver grass (*Miscanthus sinensis*), Japanese stiltgrass (*Microstegium imberbe*), mile-a-minute vine (*Polygonum perfoliatum*), Japanese knotweed (*Polygonum thunbergii*), sweet vernal grass (*Anthoxanthum odoratum*), and many others (Ketskhoveli 1959; Kolakovsky 1961; Davitadze 2001; Mikeladze et al. 2016).

Global climate change is also contributing to the spread of alien species. Therefore, it is important to determine the current state of both previously and recently introduced invasive plant species.

Materials and methods

Study area

The object of the research is the Colchis lowland. The area of botanical research includes the detection of alien species widely distributed in natural, semi-natural, and agro-ecosystems in central and southern Colchis (coastal Adjara), as well as the study of the cover-abundance of some highly invasive species.

The territory of Colchis, in a botanical and geographical sense, is an amphitheater of mountains on the eastern coast of the Black Sea. Its northern border begins in Russia, near Tuapse, and the southern border passes through Turkey, in the area of Trabzon, with the main part lying in Georgia (Fig. 1).

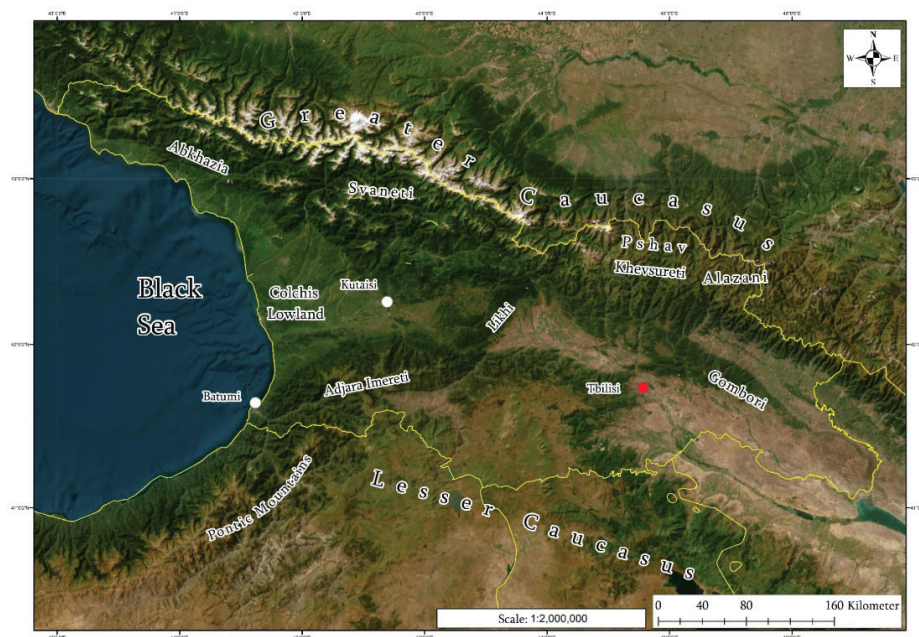


Figure 1. Map showing the research area—Colchis lowland.

Climate

The climate of Colchis is defined as moderately warm, with characteristics close to subtropical. The average annual temperature is 14 °C. The average January temperature exceeds 0 °C, but it is not uncommon for the temperature to drop very low from time to time. In Sukhumi, Poti, and Batumi, temperatures of –12 °C, –11 °C, and –8.0 °C have been recorded. Precipitation gradually decreases from the west (Batumi, 2500 mm) to the east (Sakara, 1100 mm) and also decreases from the south to the north (Sukhumi, 1400 mm). The amount of precipitation is greater in winter than in summer. Droughts are also common in late spring and early summer (Ketskhoveli 1959; Manjavidze 1982; Chitanava 2004; Climate Change Strategy of Adjara 2013).

Soils

There is a great diversity of soils in Colchis. First and foremost, red soils should be noted. In the northern part of Colchis, red soils are replaced by yellow soils, which differ from red soils in their paler color, with a yellowish-orange tint. Additionally, there are silty swamps, peaty swamps, azonally distributed alluvial, and anthropogenic soils.

Alluvial and rift soils are usually found in river valleys and marshes. Brown soils are also present in areas with red and yellow soils. Mountain forest soils, as the name suggests, are widespread in the mountain forest zone.

Coastal and riverine sands are common directly along the coastline and on river terraces. Also noteworthy are podzolic-glei soils and podzolic soils on old river terraces.

Swamp soils are primarily distributed across the Colchis lowland. These soils are divided into two types: mineral-swamp and organic-mineral swamp soils. Mineral-swamp soils are further classified into two subtypes: silty-swamp and meadow-swamp soils. Silty-swamp soils form under forest vegetation, while meadow-swamp soils develop in wet meadow coenoses. Organic-mineral swamp soils are also divided into two subtypes: subaqueous-swamp and peat-swamp (Ketskhoveli 1959; Urushadze 1997; Chitanava 2004).

Flora and vegetation

The favorable natural conditions of Colchis, the moderately warm climate, as well as the great diversity of ecological conditions, soils, and other important factors determine the richness of its flora and vegetation. The flora of Colchis includes 3596 species belonging to 932 genera and 169 families (Chitanava 2004).

The diversity of Colchis flora is associated with its variety of vegetation types and habitats. Geographically, lowland, foothill, and mountain zones are distinguished. Swamps and swamp forests are mainly found on the Colchis lowland at altitudes of 0–50 m. At 50–200 m altitude, Colchis-type vine and wetland forests dominate. Beech–hornbeam forests are also found, although very sparsely (e.g., the Paliastomi lakeside forest). At 200–500 m altitude, Colchis forests with evergreen undergrowth are prevalent (Ketskhoveli 1959).

Colchis hosts hydrophytic herbaceous vegetation and moist forests shaped by plant communities of Black Sea coastal sand dunes, grassy swamps, wooded swamps, and swampy forests.

The main species forming Colchis forests include: Caucasian wingnut (*Pterocarya pterocarpa*), hybrid poplar (*Populus hybrida*), alder (*Alnus barbata*), date-plum (*Diospyros lotus*), hornbeam (*Carpinus caucasica*), beech (*Fagus orientalis*), chestnut (*Castanea sativa*), and many others.

It is worth noting the deciduous and evergreen understory forests of the plains, characterized by distinctive species such as Colchic holly (*Ilex colchica*) and Pontic butcher's-broom (*Ruscus ponticus*). Vines include common green-brier (*Smilax excelsa*), Colchic ivy (*Hedera colchica*), silkvine (*Periploca graeca*), perfoliate honeysuckle (*Lonicera caprifolium*), common hop (*Humulus lupulus*), Colchic bladdernut (*Staphylea colchica*), cherry laurel (*Laurocerasus officinalis*), and Pontic rhododendron (*Rhododendron ponticum*).

Wetland meadows occur in peat bogs and along forest edges. The dominant species in these meadows are sharp rush (*Juncus acutus*), common reed (*Phragmites communis*), narrowleaf cattail (*Typha angustifolia*), yellow iris (*Iris pseudacorus*), and greater bur-reed (*Sparganium neglectum*). Among freshwater ponds, the following are noteworthy: Colchian water chestnut (*Trapa colchica*), floating watermoss (*Salvinia natans*), greater bladderwort (*Utricularia vulgaris*), and others (Gagnidze 1996, 2005; Kvachakidze 2009; Matchutadze et al. 2014, 2017; Akhalkatsi 2018; Resolution of the Government of Georgia 2019; Technical regulations 2019).

The uniqueness of the Colchis lowland is also reflected in the presence of globally unique habitats. These include living sphagnum peatlands (percolation-type sphagnum peatlands and groundwater-fed fen-type minerotrophic peatlands), relict forests with peat cover, natural freshwater ponds, coastal sand dunes, natural lakes and rivers, and wetland meadows.

Fieldwork

Botanical expeditions were conducted from 2021 to 2023 to assess the current status of alien plant species in the Colchis lowland and to identify the most widespread ones. Research was carried out across various habitats, including natural, semi-natural, and agro-ecosystems.

For six invasive species selected from among the widely distributed ones—Canadian goldenrod (*Solidago canadensis* L.), honey locust (*Gleditsia triacanthos* L.), false indigo-bush (*Amorpha fruticosa* L.), common ragweed (*Ambrosia artemisiifolia* L.), Brazilian vervain (*Verbena brasiliensis* Vell.), and bur cucumber (*Sicyos angulatus* L.)—the overall projectional coverage, frequency, coverage, and density of each species were determined using the Braun-Blanquet method, with quadrats placed within the studied cenoses (Braun-Blanquet 1965). Transects were marked in Kolkheti National Park and the Chorokhi Delta.

At these sites, 40 transects were established for each of the invasive alien species (IASs) (2 m wide × 50 m long). To determine the density (expressed as the number of individuals per plot), frequency, and coverage of the IASs, 10 plots (1 × 1 m), spaced five meters apart, were studied. A total of 400 plots were assessed for the six IASs. This was done twice during the vegetative period—first at the beginning and later when the IASs were flowering

and fruiting. A total of 1600 records were collected during the three years of the study. Based on these results, mean values for each species and period were calculated.

The nomenclature for the plant species follows “Plants of the World Online” (POWO 2023).

Results and discussion

Based on botanical expeditions and research carried out in the Colchis lowland from 2021 to 2023, 30 alien species were identified as widely distributed in its ecosystems (Table 1).

Table 1. Alien plant species occurring in the Colchis lowland with invasive behavior.

Scientific name	Common Name	Family	Life form	Origin
<i>Ailanthus altissima</i> (Mill.) Swingle.	Tree of heaven	Simaroubaceae	Phanerophyte	East Asia
<i>Ambrosia artemisiifolia</i> L.	Common ragweed	Asteraceae	Therophyte	North America
<i>Amorpha fruticosa</i> L.	False indigo	Scrophulariaceae	Phanerophyte	North America
<i>Andropogon virginicus</i> L.	Broomsedge bluestem	Poaceae	Hemicryptophyte	Tropical & Subtr. America
<i>Cenchrus longispinus</i> (Hack.) Fernald.	Spiny burr grass	Poaceae	Therophyte	North America
<i>Buddleja davidii</i> Franch.	Butterfly-bush	Scrophulariaceae	Phanerophyte	East Asia
<i>Clerodendrum bungei</i> Steud.	Rose glory bower	Lamiaceae	Phanerophyte	East Asia
<i>Commelina communis</i> F.Muell.	Asiatic dayflower	Commelinaceae	Therophyte	East Asia
<i>Conyza canadensis</i> (L.) Cronquist. / <i>Erigeron canadensis</i> L.	horseweed	Asteraceae	Therophyte	North America
<i>Crassocephalum crepidioides</i> S. Moore.	Thickhead	Asteraceae	Therophyte	South America
<i>Gleditsia triacanthos</i> L.	Honey locust	Fabaceae	Phanerophyte	North America
<i>Houttuynia cordata</i> Thunb.	Chameleon plant	Saururaceae	Hemicryptophyte	South East Asia
<i>Hydrocotyle ramiflora</i> Maxim.	Pennywort	Araliaceae	Chamaephyte	East Asia
<i>Juglans ailantifolia</i> Carrière.	Japanese walnut	Juglandaceae	Phanerophyte	East Asia
<i>Ligustrum lucidum</i> Ait.	Glossy privet	Oleaceae	Phanerophyte	East Asia
<i>Lonicera japonica</i> Thunb.	Japanese honeysuckle	Caprifoliaceae	Phanerophyte	East Asia
<i>Miscanthus sinensis</i> Andersson.	Chinese silver grass	Poaceae	Criptophyte	East Asia
<i>Paspalum paspaloides</i> (Michx.) Scribn.	Couch paspalum	Poaceae	Criptophyte	Tropical & Subt. America
<i>Persicaria perfoliata</i> (L.) H.Gross	Mile-a-minute	Polygonaceae	Therophyte	East Asia
<i>Persicaria thunbergii</i> (Siebold & Zucc.) H.Gross	Mizo-soba	Polygonaceae	Therophyte	East Asia
<i>Phytolacca americana</i> L.	American pokeweed	Phytolaccaceae	Criptophyte	North America
<i>Robinia pseudoacacia</i> L.	Black locust	Fabaceae	Phanerophyte	North America
<i>Rhus javanica</i> L.	Nutgall Tree.	Simaroubaceae	Phanerophyte	East Asia
<i>Sicyos angulatus</i> L.	Bur cucumber	Cucurbitaceae	Therophyte	North America
<i>Solidago canadensis</i> L.	Canadian goldenrod	Asteraceae	Hemicryptophyte	North America
<i>Spiraea japonica</i> L.	Japanese spiraea	Rosaceae	Phanerophyte	East Asia
<i>Tagetes minuta</i> L.	Mexican marigold	Asteraceae	Therophyte	South America
<i>Verbena brasiliensis</i> Vell.	Brazilian vervain	Verbenaceae	Chamaephyte	South America
<i>Xanthium strumarium</i> L.	Cocklebur	Asteraceae	Therophyte	North America
<i>Ulex europaea</i> L.	Gorse	Fabaceae	Phanerophyte	West Europe

Widespread species are grouped into 17 families and 29 genera. Nearly half of the widespread species (47%) are of East Asian origin, represented by 14 species. In second place are plants of North American origin, with 10 species, followed by South American origin with three species, tropical and subtropical American origin with two species, and West European origin with one species (Table 1; Fig. 2).

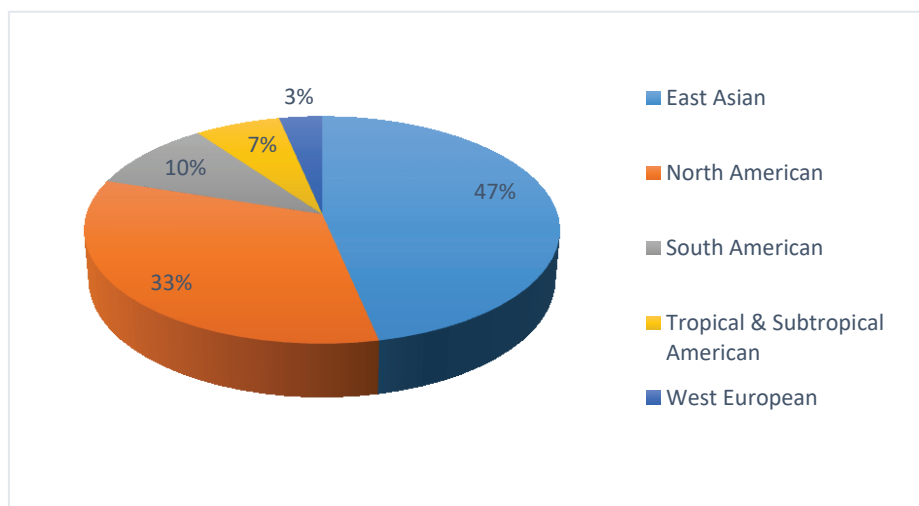


Figure 2. Origin of widespread alien plants in the Colchis lowland.

According to Raunkiaer’s classification of life forms, phanerophytes (woody plants) are represented by 12 species, while herbaceous plants are represented by 18 species. Among the herbaceous plants, therophytes (annuals) account for 10 species, and biennials and perennials for seven species. Among the perennial herbaceous plants, hemicryptophytes are represented by three species, chamaephytes by two species, and cryptophytes by three species (Tables 1, 2).

Table 2. Life form spectrum of widespread species in the Colchis lowland.

#	Life Form	Amount of species	Species in %%
1	Phanerophytes	12	40
2	Therophytes	10	33
3	Hemicryptophytes	3	10
3	Cryptophytes	3	10
4	Chamaephytes	2	7
5	Total	30	100

From the widespread species, *Amorpha fruticosa*, *Ambrosia artemisiifolia*, *Gleditsia triacanthos*, *Sicyos angulatus*, *Solidago canadensis*, and *Verbena brasiliensis* are typical invasive species, as confirmed by studies conducted using the quadrat method in selected transects and by the characteristics observed in their distribution areas.

The average data obtained for the species selected in the Chorokhi Delta (*Ambrosia artemisiifolia*, *Sicyos angulatus*, *Solidago canadensis*, and *Verbena brasiliensis*) and for the species selected in Kolkheti National Park (*Amorpha fruticosa*, *Ambrosia artemisiifolia*, *Gleditsia triacanthos*, and *Solidago canadensis*) are presented in Table 3 and Figs 3–8.

Table 3. Results of studies on IASs in Kolkheti National Park and the Chorokhi Delta.

Species	Selected area	Density 1 m ²	Frequency %	Cover %
<i>Verbena brasiliensis</i> Vell.	Chorokhi Delta Kolkheti Nat. Park	16	94	83
<i>Sicyos angulatus</i> L.		12	90	85
<i>Ambrosia artemisiifolia</i> L.		57	100	44
<i>Solidago canadensis</i> L.		44	64	74
<i>Gleditsia triacanthos</i> L.		11	48	40
<i>Amorpha fruticosa</i> L.		13	88	80

As the data presented in Table 3 show, in the selected quadrats, the average density of common ragweed (*Ambrosia artemisiifolia*) is 57. Common ragweed is dominant in its distribution area and is found in all marked quadrats, resulting in a frequency of 100%. As an annual plant, ragweed completes its vegetation period with the maturation and dispersal of a large number of seeds, which have a high germination capacity. After germination, some seedlings die due to competition within the species and between species. Additionally, due to the high density, plants growing close together are unable to bloom, resulting in an average coverage of 44% in the quadrats. For individual specimens, coverage ranges from 90–100%, a result of the plant's intensive growth and branching (Fig. 3).

Brazilian vervain (*Verbena brasiliensis*) exhibits the characteristics of a perennial plant. Under mild winter conditions, it typically continues its vegetative growth, and in early spring, new shoots begin to develop—both from the previous year's stems and from root sprouts. Due to the lack of space in the quadrats for additional shoots, and considering the plant's size, the number of individual plants is relatively low, with an average density of 16 per quadrat. In addition to vegetative reproduction, Brazilian vervain also reproduces generatively, characterized by abundant fruiting, effective seed dispersal, and the colonization of new areas. As a result, its frequency in the marked quadrats is quite high, reaching 94%. The plant's morphological traits and patterns of growth and development are also reflected in its coverage, which is similarly high—averaging 83% (Fig. 4).

**Figure 3.** *Ambrosia artemisiifolia* L.



Figure 4. *Verbena brasiliensis* Vell.

The germination capacity of bur cucumber (*Sicyos angulatus*) seeds is relatively low. The average number of individuals in the studied quadrats is 12, with an average frequency of occurrence of 90%. Bur cucumber is an annual, creeping plant characterized by rapid and vigorous growth. The average stem length ranges from 6 to 8 m, although specimens with stems measuring 12 to 16 m or more have been recorded. The plant also exhibits strong branching and uses other vegetation for support, often covering it almost entirely. The average coverage is 85% (Fig. 5).

The first specimens of Canadian goldenrod (*Solidago canadensis*) were recorded in Georgia in the 1920s, although its widespread distribution began toward the end of the last century. According to recent data, it is now found



Figure 5. *Sicyos angulatus* L.

throughout the entire Colchis lowland. The plant is characterized by relatively high seed germination capacity. The number of individuals in the quadrats is quite high, with an average density of 44 per m². Its frequency of occurrence in the study areas is also considerable, averaging 64%. In addition to seed reproduction, the plant also reproduces vegetatively via renewal buds that develop on its rhizomes—a process that continues nearly throughout the entire growing season. As a result, its coverage is also high, averaging 74% (Fig. 6).



Figure 6. *Solidago canadensis* L.

Honey locust (*Gleditsia triacanthos*) is a perennial, deciduous woody plant. It was introduced to Georgia in the early 20th century and was primarily used in forest plantations and for establishing windbreaks. However, the tendency for naturalization (wilding) in windbreaks and surrounding areas has been increasing each year. It is fairly widespread in the selected transects, particularly in the Katsoburi Forest Reserve. Despite being a woody species, both newly emerged seedlings (10–15 cm) and more mature ones (2–3 m tall) are abundant. As a result, the average density in the quadrats is 11 individuals. The species is present in nearly half of the surveyed transects, with a frequency of occurrence of 48%. In terms of coverage, the study area includes newly emerged seedlings, 2–3-year-old plants, mature specimens, and resprouts from cut stumps. This combination leads to almost 100% coverage in some transects. In areas without mature trees—where only new shoots are present—coverage averages around 40% (Fig. 7).

False indigo (*Amorpha fruticosa*) is a perennial, deciduous woody shrub that has been present in Georgia since the early 20th century. According to scientific literature from the 1940s, signs of naturalization were already observed in some areas. By the end of the 20th century, its widespread wilding and expansion had begun, particularly across western Georgia and the Colchis lowland. Numerous populations have been recorded in the selected transects. False indigo reproduces both by seed and by producing numerous lateral root shoots. In transects where it has spread by seed, the average density is 13 individuals per quadrat. Over time, many of these plants die off, while others develop into



Figure 7. *Gleditsia triacanthos* L.



Figure 8. *Amorpha fruticosa* L.

large, well-established bushes with numerous lateral shoots—often with a single mature bush occupying an entire quadrat. As a result, both frequency (88%) and coverage (80%) are high in the selected transects and quadrats (Fig. 8).

Conclusion

The Colchis lowland is one of Georgia's unique ecoregions, rich in biodiversity. However, in recent decades, due to anthropogenic impacts and climate change, alien species have become widespread. These species pose a threat to local flora and fauna by competing with native plants, altering soil composition, and disrupting local ecosystems.

As studies have shown, the spread of alien species in the Colchis lowland has been occurring for centuries, although widespread distribution began in the 1930s.

Based on literature sources and botanical expeditions, 30 widespread species have been identified, which are distributed throughout Colchis. We understand that the list of identified species in the Colchis lowland is not complete and will be supplemented with additional species in the future, as we plan to study the impact of invasive species on ecosystem services.

Some of the widespread species described in the Colchis lowland are typical invasive species. While some were once present in small numbers, they have recently become dominant across the entire Colchis lowland, including *Andropogon virginicus*, *Robinia pseudoacacia*, *Amorpha fruticosa*, *Gleditsia triacanthos*, *Solidago canadensis*, *Tagetes minuta*, *Verbena brasiliensis*, and others. Additionally, some species, such as *Sicyos angulatus*, have recently invaded and spread widely.

From the 30 selected species, *Amorpha fruticosa*, *Ambrosia artemisiifolia*, *Gleditsia triacanthos*, *Sicyos angulatus*, *Solidago canadensis*, and *Verbena brasiliensis* were assessed as dangerous invasive species based on the study of their growth and development, fruiting, reproduction, distribution, frequency, cover, and occurrence.

Solidago canadensis, *Verbena brasiliensis*, and *Amorpha fruticosa* were first recorded in the Colchis lowland in the 1930s–1940s. Their widespread distribution occurred over the last two to three decades, likely as a result of anthropogenic impact and climate change. Therefore, constant monitoring of alien species and their negative and positive impacts on ecosystem services is essential.

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Additional information

Conflict of interest

The authors have declared that no competing interests exist.

Ethical statement

No ethical statement was reported.

Use of AI

No use of AI was reported.

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Data availability

All of the data that support the findings of this study are available in the main text.

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