DISTRIBUTION AND INVASIVENESS OF FOUR NON-NATIVE SPECIES OF PLANTS IN ECOSYSTEMS IN THE CHOROKHI DELTA (SW GEORGIA)

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ABSTRACT

Chorokhi Delta is known for its high diversity and many habitats, which however are being threatened by invasive plants. Here, the effects of four invasive species of plants, namely *Ambrosia artemisiifolia*, *Sicyos angulatus*, *Solidago canadensis* and *Verbena brasiliensis* were studied. These species were recorded in the coastal area of the Black Sea and in particular in Georgia for the first time in the first half of the last century and *S. angulatus* is a very recent arrival. Currently, these species constitute a significant threat to biodiversity at local, national and global levels. These invasive species were monitored from 2021 to 2022. During this period, sites with high densities of the invasive species were identified. For each species, 5 transects were randomly set, and along each of them, 10 plots (1 × 1 m) were surveyed. The density, frequency, coverage and average height of the invasive plants were measured in each plot. These measurements were recorded twice per year for two years (2021–2022). All this information will be used to develop management plans aimed at preventing their further spread or control their abundance. The results indicate that *Ambrosia artemisiifolia* is the most invasive and widely distributed. *Verbena brasiliensis* and *Sicyos angulatus* are also highly competitive species that can seriously affect semi-natural habitats in the Chorokhi Delta and in agricultural land located close to the Delta. Unlike these species, *Solidago canadensis* is not widely distributed in the area studied. However, its ability to survive in a wide range of habitats and clonal growth indicate that it is potentially a highly dangerous invasive species, which in the future is expected to expand its range and severely affect the semi-natural ecosystems and agricultural land in the Chorokhi Delta. The results of the present study demonstrate the high adaptability of the species studied and their potential for spreading further in the near future.

Keywords: environmental effect; foreign origin; Georgia; invasive species (IAS); Kolkheti

Introduction

Currently, one of the most important threats to biodiversity are non-native invasive species (IAS), which are locally threatening the survival of certain species, specific populations and natural habitats. As the distribution of most invasive plants is climate-driven, they can colonize areas and habitats outside of their natural distribution, where they may thrive and cause ecological, economic and human health problems (Pyšek 1995; Richardson et al. 2000; Pimentel 2005; Pimentel et al. 2005; Richardson and Pyšek 2006; Simberloff et al. 2013; Blackburn et al. 2014; Colautti et al. 2014; Regulation EU 1141/2014; Mikeladze 2015; Aderoju et al. 2020).

The occurrence of non-native invasive plants (IASs) in Georgia was first recorded many years ago and new ones are still arriving. They are particularly abundant in the Kolkheti lowlands, which is in the Adjara floristic region that has a very favourable climate and diverse flora (Davitadze 2001; Davitadze 2002; Kikodze et al. 2010; Fisher et al. 2018; Mikeladze et al. 2019; Mikeladze and Sharabidze 2020; Mikeladze et al. 2021). From 1975 to 2000, 50 new non-native species of plants were recorded by Davitadze (2001) in the Adjara region, including c. 20 that were new for the flora of Georgia (*Tradescantia fluminensis* Vell., *T. virginiana* L., *Ophiopogon japonicus* (L.f.) ker. *Solanum pseudocapsicum* L., etc.). Moreover, between 2010 and 2020, several new IASs (*Sicyos angulatus* L., *Verbena brasiliensis* Vell., *Maclura tricuspidata* Carriere., *Lobelia urens* L., *Solidago canadensis* L., *Mazus pumilus* (Burm. f.) Steenis) were found for the first time in the Adjara region (Mikeladze et al. 2015; Mikeladze et al. 2017; Mikeladze et al. 2019; Mikeladze and Sharabidze 2020; Mikeladze and Bolkvadze 2021).

The increase in the distribution of IASs is closely related to the rapid increase in cross-border traffic that has greatly facilitated the transport of IASs from one region to another (Davitadze 2001; Simberloff 2013). The study of their distribution and effects on the native flora was significantly limited in restricted areas for decades, which resulted in little scientific data on their origin, rate of spread and the consequences up to now. The valley of the Chorokhi river and Chorokhi Delta in Georgia was a restricted area for political reasons.

The valley of Chorokhi river, as a cross-border crossing between Turkey and Georgia, was closed for most people for centuries (16th–19th). In the last century, there was a Soviet military base in the area, which covered more than 300 ha of the Chorokhi Delta. For military purposes, this place, as well as the surrounding areas

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Table 1 Identified target invasive alien species in the study areas.

Scientific name	Common Name	Family	Life form	Origin	Pathway of introduction
Ambrosia artemisiifolia L.	Common ragweed	Asteraceae	Therophyte	North America	Unintentional by human
Verbena brasiliensis Vell.	Brazilian vervain	Verbenaceae	Chamaephyte	South America	As an ornamental plant, by human
Sicyos angulatus L.	Bur cucumber	Cucurbitaceae	Therophyte	North America	Accidental
Solidago canadensis L.	Canadian goldenrod	Asteraceae	Hemicryptophyte	North America	As an ornamental plant, by human

were restricted and thus inaccessible for most people, including even for scientific purposes. Today, the territory of the former military base is now a pasture, hunting and entertainment facility. There are car parks nearby for vehicles transporting cargo through Turkey to various countries in Asia and Europe via the Sarpi customs point, which is the main trade and highway corridor through the Caucasus and main route by which many plants of foreign origin spread and became established in the surrounding areas.

Chorokhi Delta is known for its high diversity of plants and many habitats, which is why it is part of the "Emerald Network" – Emerald site: Chorokhi Delta-GE0000054 (Evans et al. 2019; Archuadze et al. 2021) and a Special Protection Area (SPA) for birds in Georgia (SPA 15) and also an Important Bird and Biodiversity Area (IBA; GEO32) (Paposhvili et al. 2016; Archuadze et al. 2021). The delta is an important area for overwintering and migrating birds. Specifically, the large numbers of fish that are present at the mouth of the river are a rich source of food for birds for replenishing the energy used during migration. As a result, Chorokhi Delta is a very important habitat for a large number of birds. The delta is also where many local, rare and endangered plants occur (*Trapa colchica* Albov, *Marsilea quadrifolia* L., *Paliurus spina-christi* Mill., *Ruscus colchicus* Yeo, *Pancratium maritimum* L., *Periploca graeca* L., *Rubus adzharicus* Sanadze, and many others).

Currently, there are four highly invasive ISAs recorded in the Chorokhi Delta; the common ragweed (*Ambrosia artemisiifolia*), bur cucumber (*Sicyos angulatus*), Brazilian vervain (*Verbena brasiliensis*) and Canadian goldenrod (*Solidago canadensis*). Of these species, three are of North American origin and one of South American origin (Table 1).

A. artemisiifolia, S. canadensis and *V. brasiliensis* were first recorded in Georgia in the first half of the last century along coastal areas of the Black Sea. Of these species, *A. artemisiifolia* and *S. canadensis* are widely distributed in both natural habitats and agroecosystems. *V. brasiliensis* began to spread rapidly in the early decades of the current century. *S. angulatus* is a recently recorded ISA in Georgia as it was first recorded 15 years ago in the Chorokhi valley and has now been growing for 5 years in the Chorokhi Delta.

A. artemisiifolia was first recorded in Georgia at the beginning of the last century and in the Adjara (Georgia) floristic area in 1938 (Davitadze 2001). *V. brasiliensis* was first recorded by Verloove (2006) based on a specimen of *Verbena* in the herbarium of the Belgium Botanical Garden, which was collected in 1979 by Vladimir Vashak near Sokhumi, who first identified it as *V. hastata*, but after studying the herbarium specimen identified it as *V. brasiliensis*. Early, in 1945–1946, this plant was recorded by Kolakovskii (1986) and over the last ten years, *V. brasiliensis* has been recorded growing near most highways and railway stations, at the edges of canals (waterway), along the sides of rivers in the lowlands of Western Georgia. In 2014–2015, *V. brasiliensis* was widely recorded in both humid and dry places (Mikeladze et al. 2017) mainly along the coast, roads, railroads, in ruderal areas and near canals and rivers, at deserted building sites and landfills sites. It grows in a variety of soils: red, black, shingle and sandy soils etc., especially in humid and secondarily damaged habitats.

Bur cucumber (*Sicyos angulatus*) was first recorded in Georgia in 2012 growing in agricultural land in the Chorokhi River Valley (Mikeladze et al. 2015). Its abundance and frequency of occurrence indicates it must have been present much earlier than when first recorded. Based on information provided by local residents, this species was present 10–15 years ago, that is around 2000, initially in small colonies at the edges of the river and then spread into agricultural areas. In 2014, a number of individuals of *Sicyos* were reported in the Chorokhi Delta. Currently it is widespread in the western part of Georgia, especially on moist soils along the edges of rivers, in agricultural land and in semi-natural habitats.

Solidago canadensis was first recorded in Georgia in the surroundings of Ochamchire in 1920s. After that, it spread into the other floristic districts in western Georgia and was widely distributed at the beginning of the 21st century. The first individuals of *S. canadensis* in the Adjara floristic region were recorded in 2011. In 2019, few more individuals were recorded at the Batumi landfill and in the Chorokhi Delta (Mikeladze and Bolkvadze 2021). This species is widely distributed in South Kolkheti, occurring along roadsides, railways, in ruderal areas, along edges of canals and rivers, in abandoned construction sites, wetlands and degraded cleared forests.

Based on the above, the aim of the present study is to present the results of monitoring the above mentioned IASs, which are common in the Chorokhi Delta. Knowledge of their current status is very important as it can be used to develop management plans for preventing their further spread and reducing their abundance.

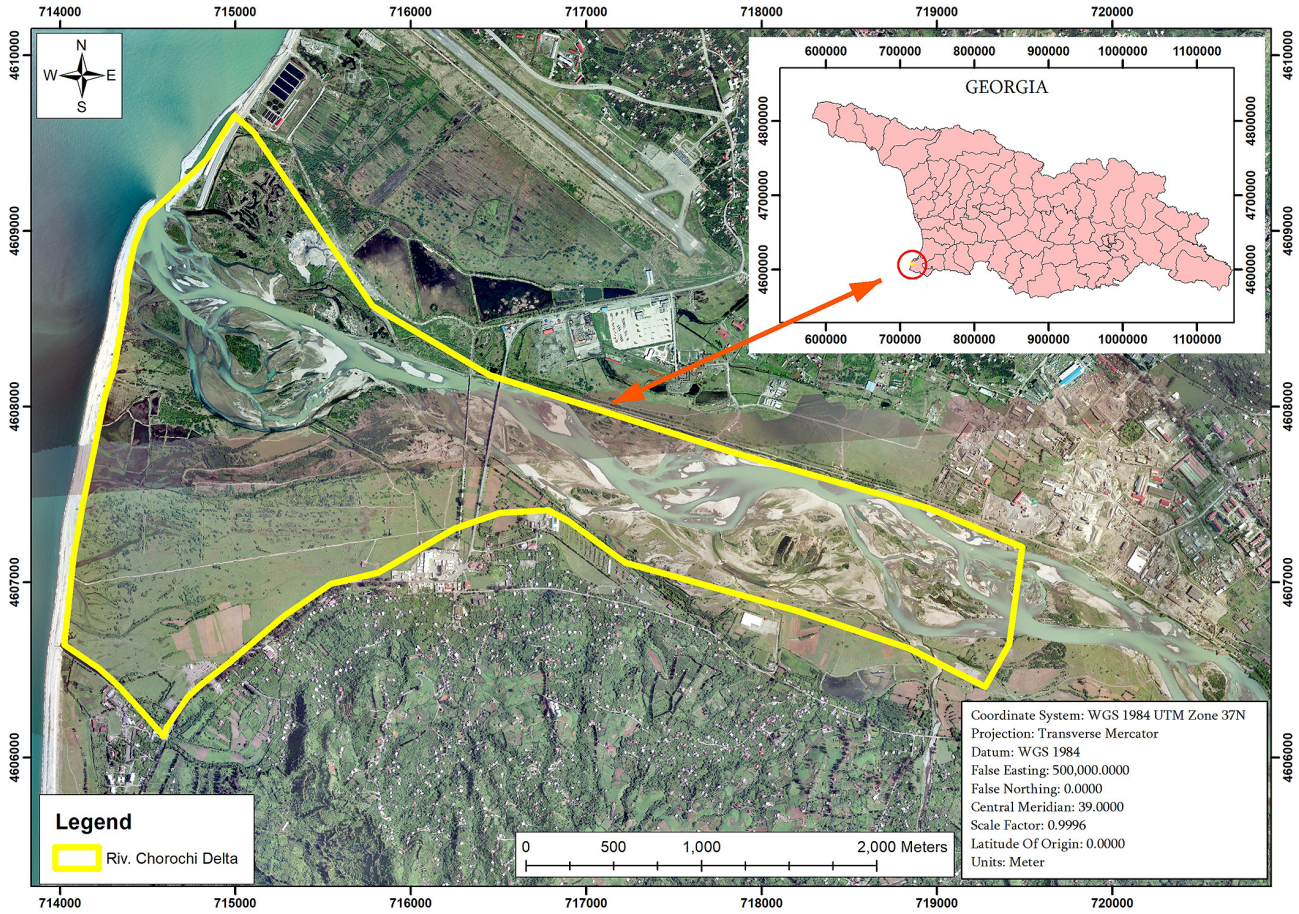

Fig. 1 Map showing the location outlined in yellow of the Chorokhi Delata where the 4 IASs were studied (700ha).

Material and Methods

Study area

The area studied is in the southwestern part of Georgia (floristic area of Adjara) and includes the Delta of the Chorokhi river, which is in the area between the border with Turkey and the Korolistskali river. In this area is a Special Protection Area (SPA) for birds for which the geographical coordinates are: 41°35.844′N / 41°33.922′E, which encompasses approximately 2,232.337 ha with an altitudinal gradient of 0 to 30 m (Paposhvili et al. 2016). The area surveyed for IASs included only semi-natural habitats in which the plant communities were only slightly altered. The total area surveyed was approximately 700 ha (Fig. 1).

Climate

Geographically, Adjara consists of two parts one close to the coast and the other inland. The coastal area mainly consists of lowlands surrounded in the east by foothills and the climate is humid subtropical. Most of the year the prevailing wind is from the west and is humid, whereas in winter it comes from inland. The average annual temperature is 13–15 °C and that of the coldest month is 5.9–7.5 °C and is rarely less than −8 °C. In the warmest month (July–August), the average temperature is 22–23 °C, and highest temperature 39–40 °C. The average humidity is 80–87% (Manjavidze 1982; Climate change strategy of Adjara 2013).

Soils

Litoral and river detritus occurs throughout the Chorokhi Delta on the seashore and on riverside terraces (*Haplic Arenosols*, according to the WRB – World Reference Base for Soil Resources classification (FAO 2023). Alluvial meadow soils (Distric Fluvisols) are abundant here. These are non-carbon, loamy, medium soils. In addition to alluvial meadow soils, Mollic Fluvisols and Alluvial meadow marshy (Umbric Fluvisols) soils occur in fragments of forest vegetation in the lowlands. Furthermore, alluvial forest-meadow soils are non-carbon, light, medium and heavy loams, and alluvial meadow marshy soils differ in being sandy or clayey. On old river terraces the soils are usually Podzolic-glei (Gleic Podzol) or Podzolic (Distric Podzoluvisols) (Urushadze 1997).

Flora and vegetation

They have changed greatly as a result of human activity. On the banks of the Chorokhi River and edges of the canal, there is fragmented seaside lowland forest, where

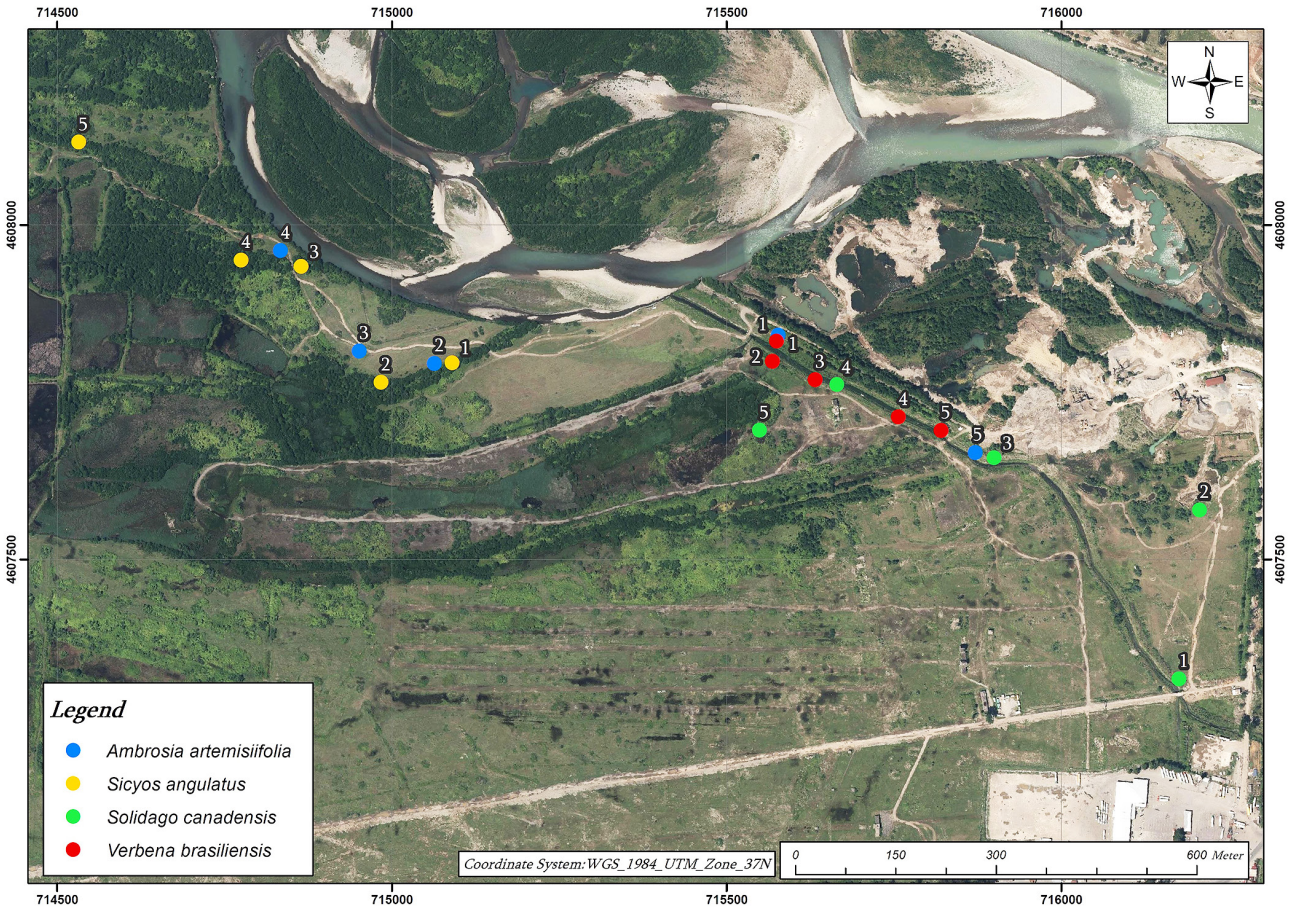

Fig. 2 Map showing the locations of the plots in the Chorokhi Delta where the four IASs were studied.

Alder (*Alnus barbata*) is the main tree. Goat willow (*Salix caprea*), white willow (*Salix alba*), Christ's thorn (*Paliurus spina-christi*), common hornbeam (*Carpinus caucasica*), Caucasian wingnut (*Pterocarya pterocarpan*), chestnut (*Castanea sativa*) and figs (*Ficus colchica*) also occur here, but are uncommon. Small clusters of bushes of Sea buckthorn (*Hippophae rhamnoides*) and more commonly species of raspberry (*Rubus anatolicus*, *R. caesius*, *R. hirtus*, *R. serpens*) occur in the delta. There are also many small ponds, in which Trapa (*Trapa colchica*, *T. Maleevi*), yellow water-lily (*Nuphar luteum*), bladderwort (*Utricularia minor*), duckweed (*Lemna minor*) occur. Around the ponds and at the edges of the canals, there are wetland-loving plants, such as slender tufted sedge (*Carex acuta*), broadleaf cattail (*Typha latifolia*), common reed (*Phragmites australis*), soft rush (*Juncus effuses*), European water-plantain (*Alisma plantago-aquatica*), bur-reed (*Sparganium neglectum*), water flag (*Iris pseudocorus*) etc.

Among the non-native woody plants, Japanese walnut (*Juglans ailanthifolia*), heart-seed walnut (*J. cordiformis*) and honeysuckle (*Lonicera japonica*) are common in this area, whereas black locust (*Robinia pseudoacacia*), many-flowered rose (*Rosa multiflora*), Japanese spirea (*Spiraea japonica*), tree of heaven (*Ailanthus altissima*) and boxelder maple (*Acer negundo*) are uncommon. There are also numerous non-native herbaceous plants.

Fieldwork

The four IASs (*Ambrosia artemisiifolia, Sicyos angulatus, Verbena brasiliensis* and *Solidago canadensis*) that are widely distributed in the Chorokhi Delta were surveyed in 2021–2022 during visits to the Chorokhi Delta. During these visits sites where the IASs were abundant were identified. At these sites, 5 transects were established in semi-natural habitats, for each of the ISAs (2 m wide × 50 m long) (Fig. 2). To determine the density (expressed as the number of individuals per plot), frequency, coverage and average height of the IASs, 10 plots (1 × 1 m) five meters apart were surveyed. A total of 200 plots were surveyed for the four IASs. This was done twice during the vegetative period first at the beginning and then when the IASs were flowering and fruiting. A total of 800 records were collected during the two years of the study. Based on these results, the mean values for each species and period were calculated.

The nomenclature for the species of plant follows the Plants of the World Online (POWO 2021). Field information for mapping was collected using a handheld Garmin GPS MAP 64st. The maps were compiled using

Table 2 Monitoring data of the studied invasive alien species in the Chorokhi Delta in the period 2021–2022.

Species	Year	Av. height (m)		Density		Frequency %		Cover %	
	Period	I	II	I	II	I	II	I	II
Ambrosia artemisiifolia L.	2021	0.1	0.47	77	40	96	100	46	20
	2022	0.1	0.48	99	57	96	100	55	44
Verbena brasiliensis Vell.	2021	1.24	1.35	6	10	90	90	40	59
	2022	1	1.28	13	16	70	94	65	83
Sicyos angulatus L.	2021	3.94	7.56	11	17	84	92	52	76
	2022	0.3	6.32	6	11	83	90	14	85
Solidago canadensis L.	2021	0.45	62.5	12	18	6	46	40	65
	2022	0.13	0.6	40	44	44	64	45	74

geographic information systems (GIS) software ArcMap. Maps were produced using the UTM WGS 1984 Zone 37N coordinate system (Fig. 2).

Results

The results of the fieldwork done during the period 2021–2022, on the frequency, density, coverage, annual growth, flowering-fruiting and rates of spread of the IASs studied are presented in Table 2.

Ambrosia artemisiifolia

Based on the results of the field surveys, *A. artemisiifolia* occurs almost everywhere (except ponds) and on all types of soils, being especially abundant along the edges of canals, in ruderal areas and edges of forests. It inhibits the growth of other species. The average height of the plants measured in the plots were 0.47–0.48 m. The height of the plants in wet woodland and along banks of canals ranges from 1.5–1.8 m (Fig. 3). New growths are abundant in meadows, but smaller due to competition from other plants and the effects of other factors (cattle grazing).

As recorded in Table 2, the average number of individuals of *A. artemisiifolia* in the first period of 2021 (period I) was higher (77 individuals) than in the second period (period II) (40 individuals). In the following year, the number of individuals recorded was higher with 99 individuals in period 1 and 57 in period 2 (Table 2, Fig. 4a). The reason for the difference in numbers recorded in the two periods each year is that this plant is an annual and ceases growing and produces a large number of seeds, the percentage germination of which is very high. In the given case, in the plots in the first period contained a large number of seedlings, many of which subsequently died due to competition within and between species. Another reason for the decrease was that the plots were subject to grazing.

The percentage cover was correlated with density. Specifically, in 2021 the coverage in the first period was 46%, whereas in the second it was 20%. In 2022, the cover values were 55% and 44%, respectively (Table 2, Fig. 4b). *A. artemisiifolia* was one of the most common IASs in the Adjara area, its frequency of occurrence in plots was 100%.

In the Adjara area (study area), *A. artemisiifolia* started germinating in March and ended in April, flowered from July to September and dispersed seed from September to October.

Fig. 3 Photograph of *Ambrosia artemisifoliia* L.

Verbena brasiliensis

Unlike *A. artemisiifolia*, the density of *V. brasiliensis* increased from the first period to the second in both 2021 and 2022 (Table 2, Fig. 5). The average number of individuals per plot increased from 6 in the first period of 2021 to 16 in the second period of 2022, (Table 2, Fig. 6a). The percentage cover of *V. brasiliensis* was positively correlated with its density. In 2021, the percentage cover in the first period was 40% and in the second 59%. In 2022, the percentage cover increased to on average 65% in the first period and 83% in the second (Table 2, Figs 6a, 6b). Based on these results percentage cover increased by 45% and frequency by 94%.

The average height of *V. brasiliensis* was 1.33 m, although some were 2.0–2.5 m tall. It is noteworthy that the frequency, percentage cover and density increased continuously over the period of the study, as shoots pro-

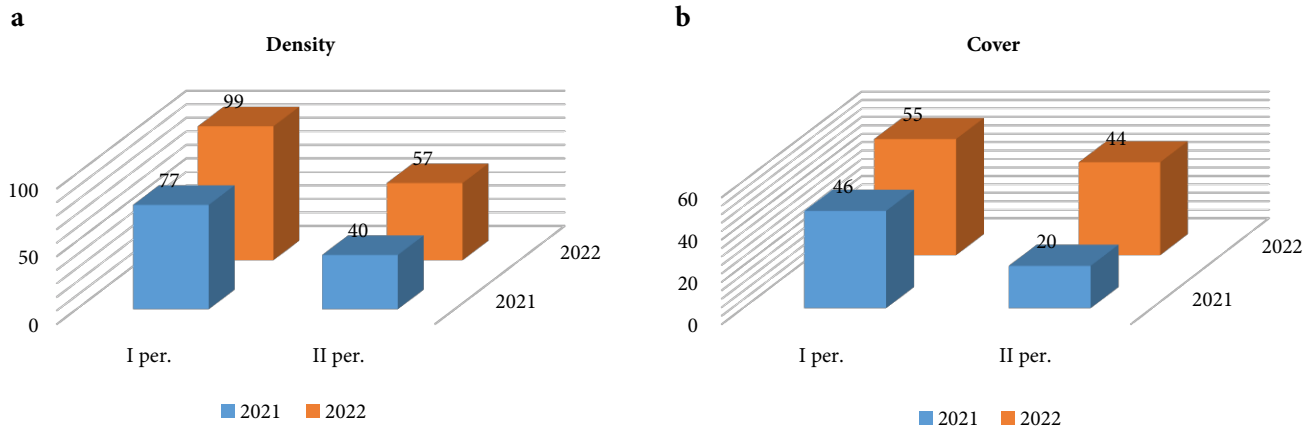

Fig. 4 *Ambrosia artemisiifolia,* a – Density; b – Percentage cover.

duced lateral shoots. Although *V. brasiliensis* in its area of origin is an annual or short-lived perennial, here it is a perennial, which enables it to dominate. Although cattle consume the thin stems, this species has a well-developed root system that can produce additional suckers, side shoots and lateral branches.

This species can produce up to 100,000 seeds in its second and subsequent years, a high percentage of which germinate, so increasing the probability of spreading further. However, this species does not occur in all types of habitats. It is especially abundant along the edges of canals, roadsides, in ruderal areas, wetlands and other places. In the Chorokhi Delta it is common on the banks of rivers, along roadsides, edges of canals, in places covered with litter and ruderal areas, where it forms large and extensive colonies.

Sicyos angulatus

The results for this species indicate it is quite abundant in the Chorokhi Delta (Table 2, Fig. 7). The spring of 2021 was particularly favourable for seed germination and it was abundant in transects and plots. In first period of 2021, average density was 11 individuals per plot and 17 in the second period. this increase was due seed germinating in summer. The spring of 2022 was colder and in the first period, the average density per plot was 6, and in the second 11. Thus, an increasing trend was recorded in both years. The percentage cover in the first period of 2021 was 52% and 76% in the second (Table 2, Figs 8a, 8b). Its frequency was 92%.

Sicyos angulatus is a climbing plant, the average length of a stem ranges from 6.5–7.5 meters, with some individ-

Fig. 5 Photograph of *Verbena brasiliensis* Vell.

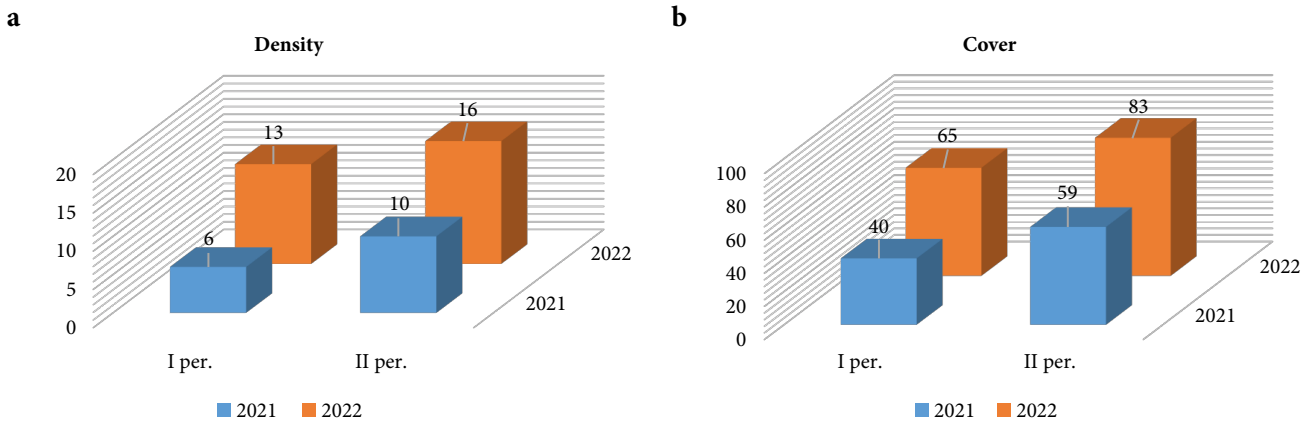

Fig. 6 *Verbena brasiliensis*, a – Density; b – Percentage cover.

Fig. 7 Photograph of *Sicyos angulatus* L.

uals reaching 12–16 m. This plant produces many lateral shoots; thus, its percentage cover increases. This species is spreading in the area studied and colonizing areas with other types of soils. *S. angulatus* mainly occurs in wetlands, along canals and rivers in the Chorokhi Delta and especially in *Alder* forests.

Solidago canadensis

This species was first recorded in the Chorokhi Delta in 2019 since then it has been spreading, but not to the extent of the other IASs (Fig. 9). In the 5 transects, plants were recorded in 3 plots in 2 transects in the first period of 2021 and 12 plots in 3 transects in the second period and in the first period in 2022 in 22 plots in 4 transects and in the second period in 32 plots in 5 transects.

In 2021, in the first period, the average number per plot was 12 and in the second period 18. In 2022, in the first period, the average number per plot was 40 and in the second period 44 (Table 2, Fig. 10a). Percentage cover of this species in the first period of 2021 was 40%, and in the second 65% and in 2022 it was 45% in the first period and 74% in the second (Table 2, Figs 10a, 10b). Based on these results, the percentage cover increased by 34% over the period of this study. Frequency of occurrence at the beginning of the study was 6% and 64% at the end, which is an indication of rate at which this species is spreading (Fig. 11).

Discussion

The geographical position of the valley of the Chorokhi river has favoured the spread of several IASs, but because of restrictions related to the military status of this area scientists were unable to study the non-native flora and the effects it was having on native plants. This is the first study on the growth, development, propagation and spread of four IASs (*Ambrosia artemisiifolia*, *Solidago canadensis*, *Verbena brasiliensis*, *Sicyos angulatus*) in the Chorokhi Delta. This study revealed that these IASs are spreading, occupying new habitats and degrading the area.

There are many papers and articles in newspapers on the effects of IASs on native fauna and flora, which are based on visual and literary descriptions (e.g., Kikodze et al. 2010; Beridze 2020). Of the four IASs studied, *A. artemisiifolia* is the most invasive. It is known for its allelopathic properties, which can prevent the growth and development of neighbouring plants (Vidotto et al. 2013). According to Bretagnolle and Chauvel (2009), *A. artemisiifolia* is among the 100 most invasive non-native plants in Europe and is continuing to spread in all European countries, where it is mostly found in agricultural fields, along roadsides and on riverbanks. In this study, it was recorded growing almost everywhere and in all types of soils. The effect of this species on the biodiversity in the Chorokhi Delta is high, especially in semi-natural ecosystems. It reduces the fertility and changes the structure of soil.

V. brasiliensis is an annual or short-lived perennial (Yeo 1990; GISD 2023). In the area studied it is a perennial and present throughout the year, with only the top of the shoots withering in winter. It propagates by means of seed and shoots from underground roots, which enables it to spread rapidly. According to the Global Invasive Species Database (GISD 2023) it is a significant inva-

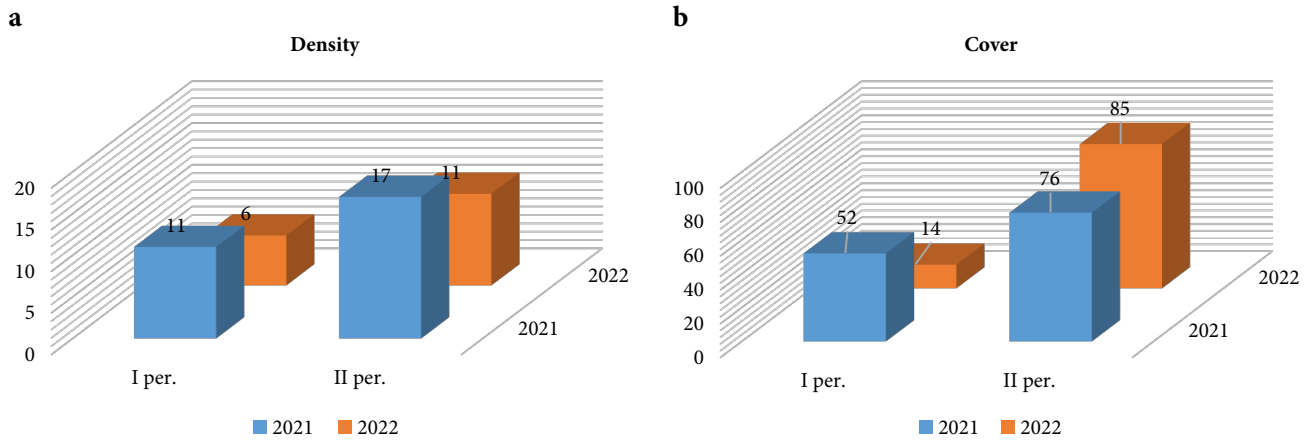

Fig. 8 *Sicyos angulatus*, a – Density; b – Percentage cover.

Fig. 9 Photograph of *Solidago canadensis* L.

sive species in the mid-south of the United States. It was first recorded in Georgia several decades ago and is now widely distributed in the lowlands in Adjara, where it is mostly found in ruderal areas, in agricultural land and near canals and rivers (Mikeladze et al. 2017). At colonized sites, this highly competitive species can alter the floristic composition. Its invasion capability is well illustrated by it being recently recorded in the northern part of Turkey (Tunçkol 2022). This species is much favoured by the local population for its beautiful flowers. As individual plant bear flower buds, flowers and mature seeds at the same time, then once it is used as an ornamental plant, people disperse large quantities of its seed, which germinates in new environments.

S. angulatus is another IAS that is recorded in a number of countries including Georgia (Tzonev 2005; Zhao et al. 2019). It was recorded in Georgia a decade ago and is considered to be one of the most aggressive IASs and currently is widespread in the western part of the country (Mikeladze et al. 2015). The seedlings of *S. angulatus* are very similar to cucumber seedlings and it only differs when flowering and fruiting, when it has many stems that completely cover surrounding plants. The lengths of the stems range from 10–12 meters (Terzioglu and Ansin 1999; Tzonev 2005). During the current study, stems up to 20 m long were recorded. Therefore, it needs to be eradicated early in its development.

The negative effect of *S. angulatus* on the native flora and vegetation in the Chorokhi Delta is very obvious in areas with moist soils where there are large populations that engulf all other plants in the area and inhibit their growth and development by producing thick and heavy mats that cover the existing vegetation. In the future, it is very likely that it will greatly damage agricultural crops, especially corn crops and citrus trees, by markedly reducing the yield and quality of these crops. The soil-climatic

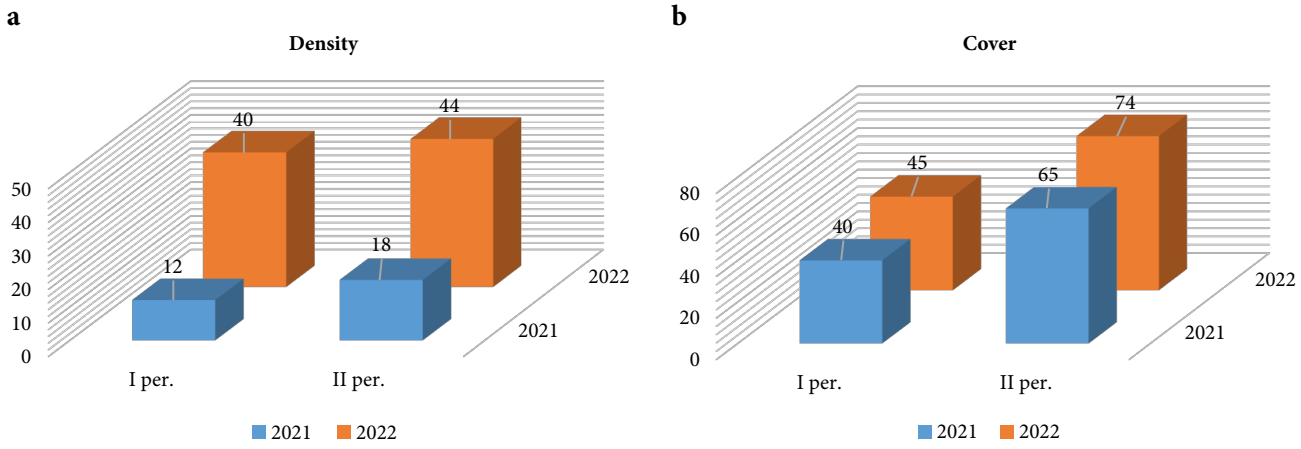

Fig. 10 *Solidago canadensis*, a – Density; b – Percentage cover.

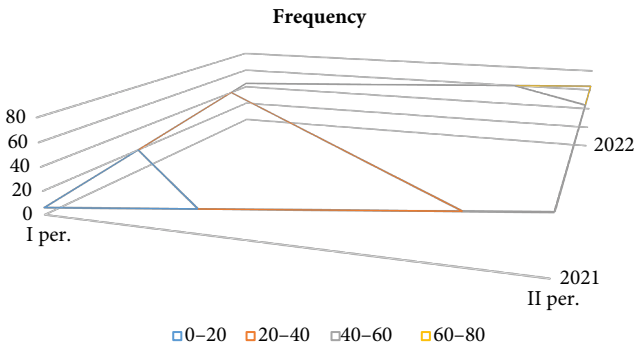

Fig. 11 Frequency of occurrence of *Solidago canadensis*.

conditions in Western Georgia, are particularly favourable for this species as it is difficult to control because after the destruction of the above-ground parts of the plant its seed can survive in the soil for at least three years.

In many European countries, *S. canadensis* is common and is continuing to spread (Kabuce and Priede 2010). However, although it is not widely spread in the Chorokhi Delta, its broad ecological tolerance and clonal growth leaves no doubt that it is a highly dangerous invasive species. By vegetative and generative propagation, it spreads rapidly producing stable and resistant colonies, which can colonize new areas. Thus, *S. canadensis* can

become and remain dominant for a long time after becoming established (Kabuce and Priede 2010). Although it has a negative effect on semi-natural ecosystems and agricultural landscapes it cannot become dominant in natural ecosystems where only single individuals occasionally occur. *S. canadensis* and *V. brasiliensis* were first recorded in the flora of Georgia in the first half of the 20th century when they were present in a small area (Kolakovskii 1982). The great increase in their distribution in the Kolkheti lowlands at the beginning of the current century and the record of first individuals in the Chorokhi Delta 5–15 years ago (Mikeladze et al. 2017; Mikeladze and Bolkvadze 2021) is attributed to global changes in climate.

Although the present study focused on four IASs in the Chorokhi Delta, an Emerald Network site and Special Protection territory for birds, which is likely to have also been affected not only by other non-native plants as there are other potentially invasive plants of foreign origin in the Chorokhi Delta that were not included in this study. This fact highlights the need for further research on the distribution and effects of non-native plants on natural and semi-natural ecosystems. Moreover, the results obtained in this study can be used to predict the current and future potential distribution of the species studied (Aderoju et al. 2020). In this way, the general public could be informed of the negative consequences associated with these IASs now and in the future. Thus, although the species studied have some positive features (e.g., people use them for decoration, birds feed on the fruits), their potential invasiveness should be taken into consideration when developing programs aimed at preventing their spread and minimizing their effect on ecosystems.

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