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Invasive alien plant species (IAPS) in the eastern region of Kosovo: a preliminary list

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Abstract. This paper presents a preliminary checklist of the invasive alien plant species (IAPS) in eastern Kosovo. This list was compiled based on a literature review and field surveys in the period between 2020-2022. The list includes 20 plant taxa with information on taxonomic affiliation (Family), life form, native range and type of habitat(s) they invaded. Most species belong to Asteraceae family, followed by Fabaceae and Balsaminaceae. Therophytes are the predominant life form. There are two genera, each with two species: *Erigeron* L. (*Erigeron annuus* (L.) Desf., *Erigeron canadensis* L.) and *Impatiens* Riv. ex L. (*Impatiens balfourii* Hook.f. and *Impatiens glandulifera* Royle), while others are represented by only one species. The majority of IAPS in the eastern region of Kosovo are from North, Central and South America (65%), followed by Asia (30%) and with only one species from Africa (5%). The habitats most heavily colonized by IAPS are the areas along roads, waste places, riverbanks and cultivated areas.

Key words: alien flora, biological invasions, plant invasions, biodiversity, Balkans.

Introduction

Kosovo is located in the western part of the Balkan Peninsula, in SE Europe. Due to its small territory (10,908 km²), it is quite rich in phytodiversity, counting between 2800-3000 taxa of vascular flora (Millaku et al., 2017). The researched region is located on the eastern side of Kosovo with an area of 6,262.54 km² or 57.4% of its territory. In the geographical literature it is also known as the "Kosovo Plain" (Çavolli, 1997), which includes not only the flat parts, but also the hilly-mountainous parts (Bytyqi, 2017).

Biodiversity, food security, health, or economic growth of an ecosystem are threatened by invasive species, i.e., non-native plants, animals, or microorganisms (Lawler et al., 2006; Pyšek et al., 2020). Invasive species pose a major threat to biodiversity worldwide, affecting many habitats (Laface et al., 2020; Gutiérrez, 2017). It is widely predicted that climate change will greatly exacerbate the threat of invasive species (Shabani et al., 2020). Globalization will inevitably lead to intentional or unintentional introduction of organisms into new environments through increased trade, transit, travel, and tourism (Gallardo & Aldridge, 2013; Dueñas et al., 2021; Kovács-Hostyánszki et al., 2022).

Invasive alien plant species (IAPS) occur in both terrestrial and aquatic habitats and may include herbs, shrubs, creepers, and/or trees (Spampinato et al., 2022). IAPS are capable of invading nearly every ecosystem on Earth and, because of their efficient use of resources (especially nutrients, water, light, oxygen, and habitat for other organisms), they can consume excessive amount of available natural resources, including a greater ability to capture light, resulting in higher rates of photosynthesis, faster

growth, and greater fruiting (Early et al., 2016; Peiris et al., 2021). As a result, they can threaten the community structure, functionality, and productivity of natural ecosystems (Vilà et al., 2011; Pyšek et al., 2012).

IAPS affect local species, communities, and ecosystems in a variety of ways (Weber, 2003; Pyšek et al., 2004; Richardson & Pyšek, 2006). They reduce the distinctiveness of biological communities at different spatial scales by reducing the species richness and abundance of native biota and their local biodiversity (Winter et al., 2009; Šilc, 2015). For example, in terrestrial environments, monospecific stands of invasive plants such as Himalayan balsam (*Impatiens glandulifera* Royle) can significantly limit understory by inhibiting seed germination, seedling establishment, and plant growth and development. IAPS also affect the biological, chemical, and physical properties of the soil (Gooden et al., 2009; Wickramathilake et al., 2013). According to Meyerson and Reaser (2002), invasive alien species have significant negative economic impacts on government, industrial, and private sectors. In many countries, the agriculture, forestry, fisheries, aquaculture, health, and conservation sectors are most affected (Caruso, 2022; Jiménez et al., 2022).

Although there are abundant data for Kosovo concerning the flora and, to some extent, plant communities (Rexhepi, 1994; Tomović et al., 2014; Millaku et al., 2013, 2017), the data concerning IAPS are entirely deficient. The study of this pressing issue in Kosovo is a relatively new topic. Until now, one publication is available (Krasniqi et al., 2011), which reports the status of three IAPS for Kosovo: *Amorpha fruticosa* L., *Reynoutria japonica* Houtt. and *Helianthus tuberosus* L., and a short country report (Maxhuni & Ibrahimi, 2016) which tabulates three other IAPS (*Ambrosia artemisiifolia* L., *Datura stramonium* L. and *Robinia pseudoacacia* L.) but provides no further information about any original survey data. In addition, the publication has been cited and referred to in numerous reports of government environmental agencies and occasionally in environmental reports of various non-governmental organizations in Kosovo (Anonymous, 2013, 2014, 2015, 2017). There were occasional scientific publications where, among others, Kosovo was also mentioned (Adamowski, 2009), or even mentioned in the context of Kosovo and Serbia, quite often without corresponding relevant specific details (Lazarević et al., 2012). As can be seen from the above data, attempts have been made to identify IAPS in Kosovo, but without a direct approach to their study and without a verified species list for these taxa in Kosovo.

Considering the importance of these taxa at local and global levels, more intensive field expeditions have been carried out, especially in the last two years, specifically targeting this group of plants. Based on this situation, the present study represents the first direct attempt to identify these plant taxa in Kosovo, more specifically in its eastern region, and to point out some taxa that are considered dangerous for the native flora.

Materials and Methods

The research area of IAPS has been the eastern region of the country (Fig. 1). Since the territory of Kosovo is divided into two main geographical areas (the eastern and the western region), then we initially decided to study IAPS only in the eastern part. In order to establish a reliable list of IAPS in the eastern region of Kosovo, we first relied on a critical analysis of the existing data about these taxa in our country (Krasniqi et al., 2011; Maxhuni & Ibrahimi, 2016), in the lists of neighboring countries as well as those further away in the Balkan Peninsula (Matevski et al., 2001; Petrova & Vladimirov, 2002; Petrova, 2004; Boršić et al., 2008; Arianoutsou et al., 2010; Stešević & Petrović, 2010; Lazarević et al., 2012; Petrova et al., 2013; Barina et al., 2014; Nikolić et al., 2014; Shehu et al., 2014; Maslo, 2016; Stojanović & Jovanović, 2018; Panjković et al., 2021; Zhuri & Imeri, 2022), while a large number of field surveys were done.

Our research so far has been based in different habitats in the eastern region of Kosovo. These field surveys focused mainly on habitats near settlements, vegetation along roads and railways, vegetation near rivers and riverbanks, and degraded habitats near settlements and mountains. The field surveys have been conducted in the period between 2020-2022. The useful data from literature sources, in addition to the general data collected from local floras, were especially publications dealing with ruderal flora (Prodanović et al., 2008; 2017; Mehmeti et al., 2009) and vegetation (Pajazitaj, 2009; Tabašević et al., 2021), vegetation and flora of meadows (Hundozi,

1982; 1983; Krasniqi et al., 2020), vegetation of hilly-mountainous areas (Krasniqi, 1966; 1972; Rexhepi, 1974; 1976; 1983; Krasniqi et al., 1981; Pajazitaj, 2012), and to some extent publications dealing with macrophytes along rivers (Bytyçi et al., 2022). Using the data obtained from the field surveys and the literature reviewed, we have provided information on taxonomic family affiliations, life forms, native origin and type of habitat(s) for each IAPS in the eastern region of Kosovo.

The taxonomic nomenclature of the plants follows the EuroMed Checklist (Euro+Med, 2006+). Life forms were assigned according to the system of Raunkier (Raunkier, 1934) designated with the following abbreviations: P – Phanaerophytes, Ch - Chamaephytes, H – Hemicryptophytes, T - Therophytes and G – Geophytes.

The determination of the native origin of the IAPS included in this list was based on available data from the international collaborative program Plants of the World Online (POWO, 2022). For each IAPS, the continent of origin is indicated with the appropriate abbreviation, with more specific information added in parentheses. The following abbreviations were used: AS = Asia, AM = America and AF = Africa.

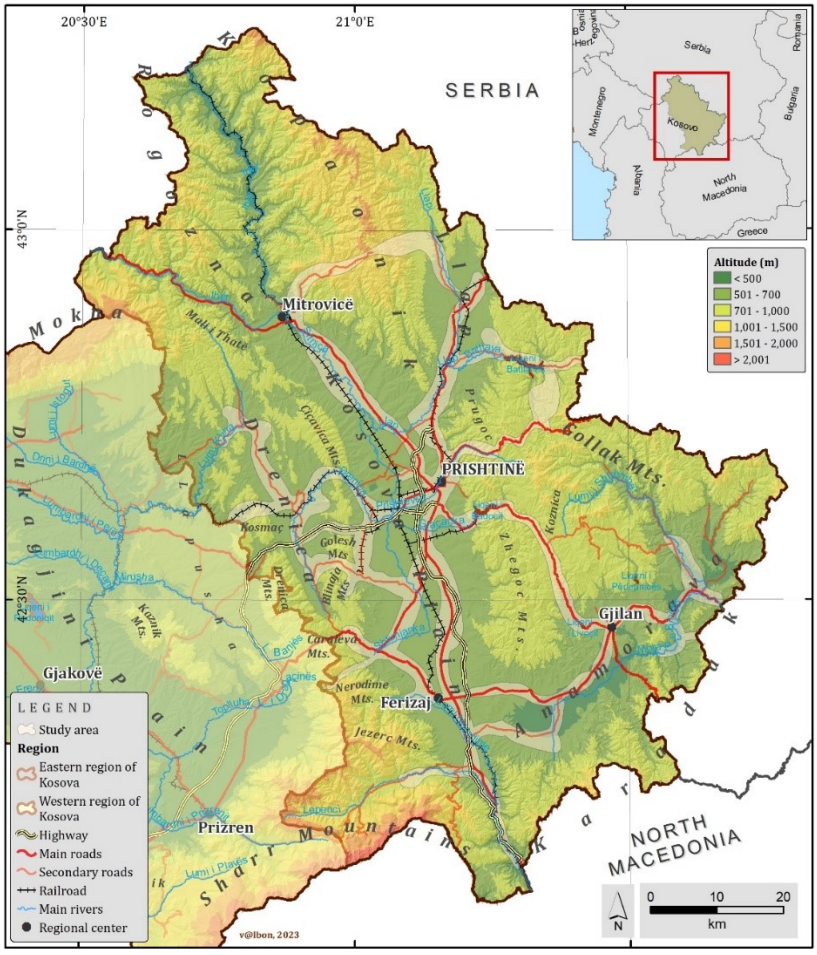

Fig. 1. Map of the study area of IAPS in the eastern region of Kosovo.

Results and Discussion

The preliminary checklist of IAPS in the eastern region of Kosovo includes a total of 20 species (Table 1). It is important to emphasize that all these species belong to the Angiosperm group and there are no representatives of other plant groups. The current list contains information on the proven occurrence of 20 IAPS. These species belong to 10 plant families. Of these, the Asteraceae family is the most species-rich with 9 species, followed by the Fabaceae and Balsaminaceae families with 2 plant species each, while the other families have only one species each (Fig. 2).

Table 1. List of invasive alien plant species (IAPS) in the eastern region of Kosovo.
Note: Explanation of abbreviations used: P - Phanaerophytes, Ch - Chamaephytes, H - Hemicryptophytes, T - Therophytes and G - Geophytes. AS - Asia, AM - America, AF - Africa.

Taxa	Family	Life form	Native range	Habitat type
Abutilon theophrasti Medik.	Malvaceae	T	AS (Central Asia to China)	Along roads
Acer negundo L.	Sapindaceae	P	AM (Canada to Honduras)	Along roads, in the parks
Ailanthus altissima (Mill.) Swingle.	Simaroubaceae	P	AS (China)	Along roads, in the parks
Amaranthus retroflexus L.	Amaranthaceae	T	AM (Mexico)	Cultivated soils, along roads, waste places, etc.
Ambrosia artemisiifolia L.	Asteraceae	T	AM (Subarctic America to U.S.A)	Railways, along roads
Amorpha fruticosa L.	Fabaceae	P	AM (U.S.A. to N. Mexico)	Along roads, waste places
Bidens frondosa L.	Asteraceae	T	AM (Canada to U.S.A)	River banks
Datura stramonium L.	Solanaceae	T	AM (Texas to Central America, Caribbean)	Along roads, cultivated soils, waste places, etc.
Erigeron canadensis L.	Asteraceae	T	AM (New world)	Along roads, wasteland, railways, etc.
Erigeron annuus (L.) Desf.	Asteraceae	T	AM (Canada to U.S.A., Nicaragua to Panama)	Along roads, wasteland, etc.
Galinsoga parviflora Cav.	Asteraceae	T	AM (Mexico to Tropical America)	Cultivated soils, waste places, etc.
Helianthus tuberosus L.	Asteraceae	G	AM (Central & E. Canada to U.S.A)	River banks, along roads, waste places
Impatiens balfourii Hook.f.	Balsaminaceae	T	AS (N. Pakistan to W. Himalaya)	Stream banks
Impatiens glandulifera Royle	Balsaminaceae	T	AS (NE. Pakistan to Nepal)	River banks
Reynoutria × *bohemica* Chrtek & Chrtková	Polygonaceae	G	AS (Russian Far East to China and Temp. E. Asia)	Along roads, waste places, river banks, cultivated soils
Robinia pseudoacacia L.	Fabaceae	P	AM (E. Central & E. U.S.A)	Along roads, river banks, waste places, etc., while has it also penetrated the oak and beech forests
Senecio inaequidens DC.	Asteraceae	Ch	AF (Southern Africa)	Along roads, waste places
Solidago gigantea Aiton.	Asteraceae	H	AM (Canada to NE. Mexico)	River banks, along roads
Sorghum halepense (L.) Pers.	Poaceae	G	AS (Macaronesia to Central Asia and Indo-China)	Along roads, cultivated soils
Xanthium spinosum L.	Asteraceae	T	AM (Central & E. Canada to Mexico, Peru to S. South America)	Along roads, waste places

The total number of IAPS reported here for eastern region of Kosovo is much lower than in most countries of the region, since only one region of Kosovo has been researched and this is only a preliminary list. But here we must take into account the fact that Kosovo is a very small country compared to some countries in the region and has no access to the sea, so we can assume that this is the reason for the lower number of IAPS. In Albania, for example, 37 IAPS are reported (Barina et al., 2014; Shehu et al., 2014; Zhuri & Imeri, 2022), in Serbia 51 (Lazarević et al., 2012; Stojanović & Jovanović, 2018), in Croatia 64 (Boršić et al., 2008; Nikolić et al., 2014), in Bosnia and Herzegovina 50 (Maslo, 2016), in North Macedonia 44 (Matevski et al., 2001), in Montenegro 50 (Stešević & Petrović, 2010), in Bulgaria 61 (Petrova & Vladimirov, 2002; Petrova, 2004; Petrova et al., 2013), and in Greece 50 (Arianoutsou et al., 2010). In total, the occurrence of 170 IAPS taxa is estimated in the Balkan Peninsula (Panjković et al., 2021).

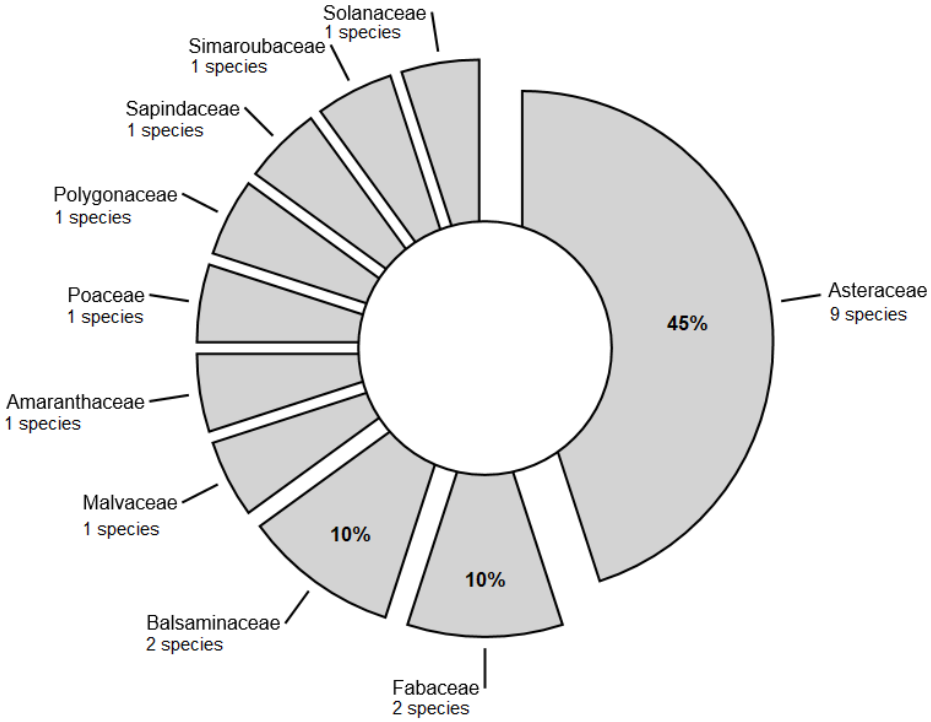

Fig. 2. Plant families with the total number of IAPS recorded in the eastern region of Kosovo.

Regarding to the plant genera, *Erigeron* L. and *Impatiens* Riv. ex L., they have two species each, while other genera are represented by only one species. In Kosovo, there are no native representtatives of the Simaroubaceae family, except for *Ailanthus altissima* (Mill.) Swingle, which is invasive alien. In addition, from the family Balsaminaceae, three species are known in Kosovo, two of which are invasive alien, while the third species: *Impatiens noli-tangere* L. is considered a native species in Europe (POWO, 2022), with temperate Eurasia as native distribution range.

The analysis of the spectrum of life forms showed the predominance of Therophytes (Fig. 3), represented by 11 species (55%). The second group was formed by Phanaerophytes, represented by 4 species (20%), followed by Geophytes with 3 species (15%), while Hemicryptophytes and Chamaephytes with only 1 taxon each (5% each). The higher representation of therophytes was already expected, since the biology of this group (annual plants) is known to complete their life cycle quickly, to be able to produce many seeds that are easy to disperse, and therefore to be very efficient plants for dispersal - invasive properties (Boršić et al., 2008).

From the results on the geographical origin of IAPS (Fig. 4), most of them in the eastern region of

Kosovo originate from America (65%). The 13 species from this continent originate mostly from the North America, with fewer species also from Central and South America. Asia forms the second group with 6 species (30%), while Africa is represented by only one species (5%). On the other hand, there are publications that report on the spread of plants from America to the region of SE Europe has accelerated in the last decades (Panjković et al., 2021).

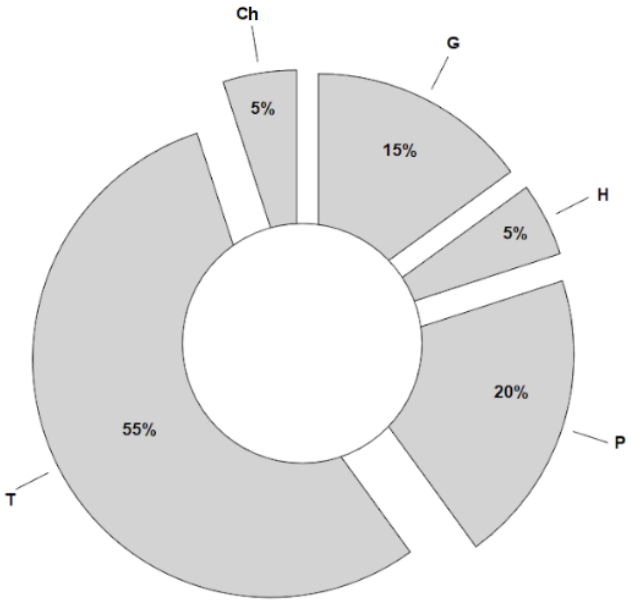

Fig. 3. Life-form spectrum of invasive alien plant species (IAPS) in the eastern region of Kosovo.

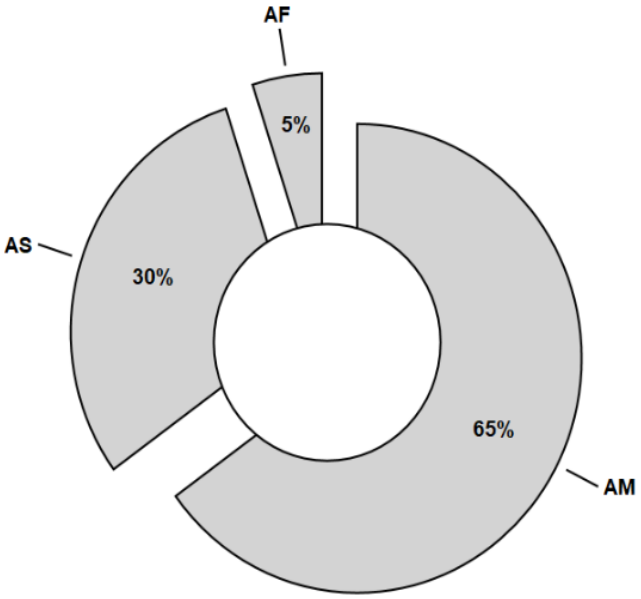

Fig. 4. Area of origin of invasive alien plant species (IAPS) in the eastern region of Kosovo.

To understand the mechanisms of invasion and to develop efficient predictive models and decision-support systems for management actions, it is essential to understand the geographic and temporal patterns of invasive species movement (Masters & Sheley, 2001), and additionally, to recognize the preferences of individual invasive alien species for habitat types (Carranza et al., 2011). Such patterns, if accurately described and quantified, can provide insight into the factors that contribute to invasions (Richardson et al., 2000; Kolar & Lodge, 2001). They also serve as the basis for predictive models that are critical to developing workable solutions, both for reducing invasion rates and their impacts as well as for reclaiming invaded landscapes.

Among the habitats where IAPS occur in the eastern region of Kosovo, anthropogenic habitats (areas along roads, waste places, cultivated areas) and riverbanks are the most affected by IAPS. A similar pattern has been reported from other studies too (Chytrý et al., 2008; Guarino et al., 2021). However, it is worth mentioning that their invasion goes beyond these habitats, as the case with *Robinia pseudoacacia* L. which has penetrated in oak and beech forests.

In general, invasive alien plants can be said to be conspicuous for rare characteristics in conquered habitats. They employ various ecological stra-tegies that increase their success rate in invading new habitats through permanent competition and interactions with native plant communities. Some of their main characteristics are: phenotypic plasticity, high dispersal ability, rapid reproduction and growth, the ability to efficiently reproduce vegetatively, the large number of seeds produced, long-lived seeds, etc. (Kunwar & Acharya, 2013).

Conclusions

This paper presents original data on the occurrence of 20 invasive alien plant species in the eastern region of Kosovo. Most of the taxa included in the list originate from the North American continent. The family with the highest number of taxa is the Asteraceae family, while

the therophyte life form has the highest proportion. The habitats with the highest proportion of IAPS were anthropogenic habitats and river habitats.

In order to present the distribution map of IAPS in eastern region of Kosovo, many more expeditions will have to be undertaken. Nevertheless, we decided to publish preliminary results, since in the wider Balkan region, only Kosovo lacks data concerning IAPS. By doing so, we hope to make a contribution to this important problem for biodiversity and to draw the attention of governmental authorities responsible for nature conservation and environmental protection to this pressing issue. Although we have compiled this list with a valuable amount of data for this plant category, our work on the overview/knowledge gain of the IAPS is still on-going.

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