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INVASIVE SPECIES IN ASS. *TRIFOLIO-AGROSTIETUM STOLONIFERAE* MARKOVIĆ 1973 IN BAČKA (SERBIA)

ABSTRACT: In the vegetation of meadows and pastures, due to climate changes and an inadequate and intensive use of hydromeliorative measures, invasive species play a significant role in the degradation of biodiversity. Secondary development of ass. *Trifolio-Agrostietum stoloniferae* Marković 1973 stands was observed in Bačka, in periodically flooded pastures. Floristic composition of these stands consists of 117 plant species, of which 94 grow in the Danube riverbank region and 97 around the Tisa river. According to the floristic analysis, *Ambrosia artemisiifolia*, *Bellis perennis, Carduus nutans, Cirsium arvense, Eupatorium cannabinum, Linaria vulgaris, Lotus corniculatus, Lythrum salicaria, Rumex crispus,* and *Trifolium repens* are characterized as invasive plants of the European region. Moreover, *Ambrosia artemisiifolia, Eleusine indica* and *Xanthium spinosum,* included in the *List of invasive species in AP Vojvodina*, are also present. *Lythrum salicaria* is regarded as one of the 100 most dangerous invasive alien species in the world.

KEYWORDS: invasive species, pasture, *Trifolio-Agrostietum stoloniferae,* vegetation

INTRODUCTION

Biodiversity conservation and environmental protection are primary concerns of contemporary society. Biodiversity reduction in ecosystems is a direct consequence of environmental changes. Expansion and retraction of species are natural phenomena that, owing to the intensive and often unfavorable human treatment, are increasingly expedited [Van Kleunen and Richardson, 2007]. By polluting habitats, humans are disrupting living conditions of many species, which consequently retreat or disappear. On the other hand,

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species that have successfully adapted to the changed habitat conditions rapidly proliferate and often become expansive. Anthropogenic factors thus strongly influence the changed relationships in ecosystems, leading to depletion of species and changes in ecosystem structures. Additional ecological pressure on the ecosystem imbalance is created by invasive plant species that further contribute to the biodiversity reduction [Wetzel, 2005]. According to the Convention on Biological Diversity, invasive species are one of the main threats to biological diversity [Šilc et al., 2012].

The main aim of the invasion ecology studies is identifying the determinants of invasiveness, many of which focus on the species' traits. Effective physiological and reproductive capacities, such as high growth rates, vitality, high plasticity and flexibility of the natural resource utilization and short life cycle, are known factors that promote invasiveness [Wetzel, 2005; Bernez et al., 2006; Van Kleunen and Richardson, 2007; Bekavac et al., 2010]. However, as the majority of the comparative studies of this phenomenon involve a small number of species, broader generalization of their findings is not possible [Van Kleunen et al., 2010]. On the other hand, it is necessary to emphasize the importance of interactions between species' traits and habitat invasiveness [Chase and Knight, 2006; Thiébvaut, 2007]. In that respect, high fluctuations in the available ecosystem resource levels have been identified as one of the key causes of invasiveness [Davis et al., 2000].

The necessity of invasive species monitoring has led to the development of international programs and databases, such as the Global Invasive Species Database − GISD (ISSG, GISP, IUCN), Delivering Alien Invasive Species Inventory for Europe − DAISIE, etc. More recent extensive research on the invasions and attempts to solve the problem of alien species includes floristic network mapping, as well as—empirically proven as more reliable—mapping using phytocoenological records [Šilc et al., 2012].

In the vegetation of meadows and pastures, in addition to climate changes, improper use, hydromeliorative measures, and conversion of meadows and pastures into arable land, invasive species have a significant influence on biodiversity degradation and decreased productivity. In the areas surrounding the rivers Danube and Tisa in Bačka, in the periodically flooded pastures in close proximity to human settlements, ass. *Trifolio-Agrostietum stoloniferae* Marković 1973 stands have developed. This association develops due to grazing, trampling and fertilization. Stands of ass. *Trifolio-Agrostietum stoloniferae* typically cover higher parts of the riverbanks, which are only temporarily flooded during high tides. In this area, the analyzed phytocoenosis is represented by stands belonging to two subassociations, the formation of which was caused by the microrelief differences.

Trifolio-Agrostietum stoloniferae subass. *agrostetosum albae* Marković 1973 stands are formed in the parts that remain hydrated throughout the year, whereas *Trifolio-Agrostietum stoloniferae* subass. *cynodontetosum* Marković 1973 stands are found in the higher parts of the riverbanks, characterized by markedly xerophilic habitat. In terms of syntaxonomic classification, ass. *Trifolio-Agrostietum stoloniferae* belongs to *Agropyro-Rumicion crispi* Nordh. 1940 alliance, *Agrostietalia stoloniferae* Oberdorf. 1967 order and *Molinio-Arrhenatheretea* Tx. 1937 class.

The aim of this paper is to demonstrate that the presence of invasive species ass. *Trifolio-Agrostietum stoloniferae* stands in Bačka can be a potential cause of biodiversity depletion and decreased pasture productivity.

MATERIALS AND METHODS

Phytocoenological studies of ass. *Trifolio-Agrostietum stoloniferae* stands in Bačka were conducted in the areas surrounding the Danube River (Sombor, Apatin, Bogojevo and Koviljski rit) and the Tisa River (Titelski breg, Žabalj-Jegrička, Bečej and Senta).

Biogeographical classification into floristic elements was performed according to Gajić [1980], and that pertaining to life forms followed Soó [1980].

RESULTS AND DISCUSSION

Floristic composition of ass. *Trifolio-Agrostietum stolonifeae* stands in the Bačka region comprises 117 plant species, of which 94 and 97 are found in the areas surrounding the rivers Danube and Tisa respectively. In the Danube region there are characteristic species of *Trifolium fragiferum* association, characteristic species of *Cynodon dactylon* subassociation, characteristic species of *Agropyro-Rumicion crispi* alliance and *Agrostietalia stoloniferae* order: *Agrostis verticillata, Rumex crispus,* and *Festuca arundinacea*, as well as characteristic species of *Molinio-Arrhenatheretea* class: *Trifolium repens, Lolium perenne, Achillea millefolium, T. pratense, Cichorium intybus, Pastinaca sativa* and *Plantago lanceolata* [Lazić, 1995; Stojanović et al., 1996; Džigurski and Nikolić, 2012]. In the area surrounding the Tisa River there are characteristic species of *Trifolium fragiferum* association, characteristic species of *Agropyro-Rumicion crispi* alliance and *Agrostietalia stoloniferae* order: *Agrostis verticillata, Rumex crispus* and *Inula britannica,* and characteristic species of *Molinio-Arrhenatheretea* class**:** *Lolium perenne* and *Andropogon ischaemum* [Stojanović et al., 2000; Džigurski et al., 2012]. Stand analysis points to the rich flora diversity of the investigated phytocoenosis, which is in line with the findings pertaining to Eastern Slavonia and Baranja, where 122 taxa were found [Šegulja and Topić, 1987]. Similarly,

80 species were identified in Srem [Butorac, 2004] and 43 in the region of northeastern Croatia [Rauš et al., 1985].

Table 1. Floristic composition of the ass. *Trifolio-Agrostietum stoloniferae* stands in the Bačka region, with life forms, floristic elements and invasiveness of the plant species, according to GISD (∗) and the *List of invasive species in AP Vojvodina* (∗∗)

Plant species	Podu-navlje	Poti-sje	Life forms	Floristic elements	Invasive spesies
Achillea millefolium L.	+	+	H.	Evr.	
Agrimonia eupatoria L.	+	+	H.	Evr.	
Agropyrum repens (L.) P. B.	+	+	G.	Evr.	
Agrostis alba L.	+	+	H.	Subevr.	
Agrostis verticillata Vill.	+	+	H.	Subm.	
Alopecurus pratensis L.		+	H.	Evr.	
Althea officinalis L.	+		H.	Subpont.-ca.	
Ambrosia artemisifolia L.		+	Th.	Adv.	*, **
Andropogon ischaemum L.	+	+	H.	Pont.-ca.-subm.	
Atriplex litoralis L.		+	Th.	Evr.	
Bellis perennis L.	+	+	H.	Subse.	*
Bidens tripartitus L.	+	+	Th.	Subse.	
Bromus arvensis L.	+		Th.-TH.	Evr.	
Bromus commutatus Schr.		+	Th.	Subse.	
Bromus tectorum L.		+	Th.	Evr.	
Calamagrostis epigeios (L.)Roth.	+		H.-G.	Evr.	
Calamintha vulgaris (L.)Druce.	+	+	H.	Cirk.	
Calystegia sepium (L.) Br.	+	+	H.	Evr.	
Capsella bursa-pastoris (L.)Med.	+	+	Th.-TH.	Kosm.	
Carduus acanthoides L.	+	+	TH.	Subse.	
Carduus nutans L.	+	+	TH (Th).	Subevr.	*
Carex distans L.	+	+	H.	Evr.	
Carex hirta L.	+	+	G.	Subevr.	
Carex praecox Schreb.	+		G.-H.	Evr.	
Carex vulpina L.	+	+	H.-HH.	Subevr.	
Cerastium caespitosum Gilib.	+		TH.-H(Ch.)	Kosm.	
Cichorium intybus L.	+	+	H.(TH.)	Subevr.	
Cirsium arvense (L.) Scop.,		+	G.	Subevr.	*
Cirsium lanceolatum (L) Scop.	+	+	TH.	Subevr.	
Convolvulus arvensis L.	+	+	H.-G.	Kosm.	
Crataegus monogyna Jacq.	+		M.	Subse.	
Crepis setosa Hall.	+	+	Th.	Subm.	
Cynodon dactylon (L.) Pers.	+	+	G.(H.)	Kosm.	
Dactylis glomerata L.	+	+	H.	Subevr.	

Daucus carota L.	+	+	Th.-TH.-H.	Subevr.	
Dipsacus laciniatus L.	+	+	TH.	Pont.-ca.-subm.	
Dipsacus sylvestris Huds.	+	+	TH.	Subse.	
Eleusine indica (L.) Gaertn.	+	+	Th.	Adv.	**
Epilobium adnatum Gris.		+	H.	Subevr.	
Erigeron canadensis L.	+	+	Th.-TH.	Adv.	
Eryngium campestre L.	+	+	H.	Subpont.-subm.	
Eupatorium cannabinum L.		+	H.	Subse.	*
Euphorbia cyparissias L.	+	+	H.(G.)	Evr.	
Festuca arundinacea Schreb.	+	+	H.	Subevr.	
Festuca pratensis Huds.	+	+	H.	Evr.	
Festuca pseudovina Hack.	+		H.	Evr.	
Galium aparine L.		+	Th.	Evr.	
Galium mollugo L.		+	H.	Subse.	
Galium verum L.	+	+	H.	Evr.	
Geranium pusillum Burm.		+	Th.	Subse.	
Glechoma hederacea L.	+	+	H.(Ch.-G.)	Evr.	
Gratiola officinalis L.	+	+	H.	Cirk.	
Heleocharis palustris (L.)R.Br		+	G.-HH.	Kosm.	
Helminthia echioides Gaertn.		+	TH.-Th.	Subm.	
Hordeum murinum L.		+	Th.	Subm.	
Inula britannica L.	+	+	TH.-H.	Subse.	
Juncus articulatus L.	+	+	H.	Cirk.	
Juncus compressus Jacq.	+		G.	Evr.	
Juncus gerardii Lois.	+		G.	Subcirk.	
Juncus inflexus L	+		H.	Subcirk.	
Kickxia elatine (L.) Dum.		+	Th.	Subatl.-subm.	
Linaria vulgaris Mill.	+	+	H.(TH.)	Subse.	*
Lolium perenne L.	+	+	H.	Subse.	
Lotus corniculatus L.	+	+	H.	Subevr.	*
Lotus tenuis W. et K.	+		H.	Subse.	
Lycopus europaeus L.	+	+	HH.	Subevr.	
Lycopus exaltatus L.	+	+	HH.	Subj.sib.	
Lysimachia nummularia L.	+	+	Ch.	Subse.	
Lythrum salicaria L.		+	H.-HH.	Pont.-ca.-subm.	*
Malva sylvestris L.	+	+	Th.-TH.-H.	Subse.	
Matricaria chamomilla L.	+	+	Th.	Evr.	
Medicago falcata L.		+	H.	Subpont.-ca.	
Medicago lupulina L.	+	+	Th.-TH.-H.	Subevr.	
Mentha aquatica L.		+	H.-HH.	Evr.	
Mentha longifolia (L.) Nath.	+	+	H.(G.)	Subse.	
Mentha pulegium L.	+	+	H.	Subse.	

Odontites rubra Gilib.	+		Th.	Subse.	
Ononis arvensis L.	+	+	H.-Ch.	Subse.	
Pastinaca sativa L.	+	+	H.	Evr.	
Phragmites communis Trin.	+	+	HH.	Kosm.	
Picris hieracioides L.	+		TH.-H.	Subpont.-ca.	
Plantago lanceolata L.	+	+	H.	Evr.	
Plantago major L.	+	+	H.	Evr.	
Plantago media L.	+	+	H.	Evr.	
Poa pratensis L.	+	+	H.	Subcirk.	
Poa trivialis L.	+		H.	Subevr.	
Polygonum aviculare L.	+		Th.	Kosm.	
Potentilla anserina L.	+	+	H.	Subcirk.	
Potentilla argentea L.	+	+	H.	Subpont.-ca.	
Potentilla reptans L.	+	+	H.	Evr.	
Prunella vulgaris L.	+	+	H.	Subevr.	
Ranunculus polyanthemus L.	+	+	H.	Subpont.	
Ranunculus repens L.	+	+	H.	Evr.	
Ranunculus sardous Cr.	+	+	Th. (-H.)	Subse.	
Rhinanthus rumelicus Vel.		+	Th.	Subsrbalk.	
Rorippa austriaca (Cr.) Bess.		+	HH.	Subpont.	
Rorippa sylvestris (L.) Bes.	+	+	H.	Subpan.	
Rumex crispus L.	+	+	H.	Evr.	*
Rumex hydrolapathum Huds	+	+	H.-HH.	Subse.	
Rumex pulcher L.	+		Th.-TH.	Subm.	
Sambucus ebulus L.	+	+	H.	Subpont.-subm.	
Setaria glauca (L.) P. B.		+	Th.	Kosm.	
Sinapis arvensis L.	+		Th.	Subevr.	
Sonchus arvensis L.	+	+	H.	Evr.	
Statice gmelinii Willd	+		H.	Pont.-pan.	
Stenactis annua (L.) Nees.		+	Th.	Adv.	
Taraxacumn officinale Web.	+	+	H.	Evr.	
Torilis arvensis (Huds.) Link.	+		Th.	Evrafr.	
Trifolium campestre Schreb.	+	+	Th.-TH.	Subse.	
Trifolium fragiferum L.	+	+	H.	Subse.	
Trifolium pratense L.	+	+	H.	Subevr.	
Trifolium repens L.	+	+	H.	Subevr.	*
Urtica dioica L.	+	+	H.	Evr.	
Verbena officinalis L.	+	+	Th.-H.	Kosm.	
Xanthium italicum Mor.	+	+	Th.	Adv.	
Xanthium spinosum L.	+	+	Th.	Adv.	**
Xeranthemum annum L.	+		Th.	Pont.-subm.	

Life form spectrum of the analyzed pasture vegetation indicates the dominance of hemicryptophytes (52.99%), including the species of the highest diagnostic significance and the highest values regarding abundance and ground cover: *Trifolium fragiferum*, *Agrostis verticillata, Rumex crispus, Festuca arundinacea, T. repens, Lolium perenne, Achilea millefolium, T. pratense*, etc. Significant presence of therophytes (27.35%) indicates warmer climate effects. Based on the percentage participation, these are followed by hemiterophytes (7.69%) and geophytes (6.84%). The presence of hydrophytes (3.42%) was noted in microdepressions that are moist throughout the larger part of the growing season. Hamephytes and phanerophytes are represented by a single taxon each (0.85%). Like other meadow phytocoenoses, the studied one is of therophytic-hemicryptophytic character. Tomić et al. (2010) indicate that in Karakuša region (Srem), the ass. *Trifolio-Agrostietum stolonifeae* is dominated by hemicryptophytes (64.3%). Much lower participation of therophytes (11.9%) is a result of the specific microclimatic conditions of this hunting region, which is under intense anthropogenic-zoogenic influence. Butorac [2004] also characterized the analyzed association found in Mt. Fruška Gora loess plateau as a therophytic-hemicryptophytic (with 57.50% hemicryptophytes and 23.75% therophytes). According to Jovanović-Dunjić [1969], the percentage increase in therophytes and decrease in hemicryptophytes, starting from parts of Croatia characterized by humid climate, through Serbia, to Macedonia is primarily driven by climatic conditions. Hence, the therophytes/hemicryptophytes ratio, proportional to the reduction in humidity in meadow phytocoenoses, points to the transitional ecological character of the studied region.

Phytogeographical analysis of the ass. *Trifolio-Agrostietum stolonifeae* stands in Bačka region indicates the dominance of plants belonging to the groups characterized by the floristic elements of wide distribution (61.53%). Eurasian group of floristic elements is the most common (42.73%), followed by cosmopolitan (7.69%), circumpolar (5.98%) and adventive (5.13%) groups. Groups of floristic elements of narrower distribution participate with 38.45%, and comprise Central European (19.66%), Pontic-Central Asian (11.96%), sub-Mediterranean (5.98%) and sub-Atlantic (0.85%) groups.

Based on the floristic analysis, *Ambrosia artemisiifolia*, *Bellis perennis, Carduus nutans, Cirsium arvense, Eupatorium cannabinum, Linaria vulgaris, Lotus corniculatus, Lythrum salicaria, Rumex crispus* and *Trifolium repens* were identified, according to Global Invasive Species Database (ISSG, GISP, IUCN), as invasive plants for the European region. Within the aforementioned species, *Lythrum salicaria* is regarded as one of the 100 most dangerous invasive alien species in the world. Among the stands examined in this study, in addition to the already mentioned *Ambrosia artemisiifolia, Eleusine indica* and *Xanthium*

spinosum are also included in the *List of invasive species in AP Vojvodina* (IASV 2011) [Table 1]. Life form analysis of the identified invasive species (58.33% hemicryptophytes, 25% therophytes, and 8.33% hemiterophytes and geophytes each) is proportional to the life form spectrum of the total ass. *Trifolio-Agrostietum stolonifeae* flora. From the geo-floristic perspective, the invasive species are dominated by the widely distributed floral elements (66.67%). This agreement in the biological spectrum analysis and that pertaining to the areal invasive species types on the one hand, and the total stand flora on the other, confirms excellent adaptability of invasive species, in particular to the specific vegetation relationships within this grassland phytocoenosis, and to the climatic conditions as well. Thompson and Davis [2011] also argue that the invasive species characteristics vary only slightly from the indigenous species. Therefore, in order to explain the process of a successful invasion, in addition to understanding the biological characteristics of the invasive species, further research must include interactions between invasive species and autochthonous flora [Keller et al. 2011].

Although the 12 invasive species of stands found in the analyzed pasture vegetation are present in smaller numbers and cover smaller area (with the exception of *Trifolium repens, Ambrosia artemisifolia* and *Cirsium arvense*), monitoring their expansion is necessary in order to prevent structure distortion and floristic composition impoverishment [Džigurski and Nikolić, 2012]. In addition, these species play a significant role in the reduction of pasture productivity because they interfere with the growth of desirable forage species. More specifically, apart from *Trifolium repens* and *Lotus corniculatus*, which are useful forage plants, the remaining species are, according to Mrfat-Vukelić et al. [1996], worthless (*Ambrosia artemisiifolia*, *Bellis perennis, Eupatorium cannabinum, Lythrum salicaria* and *Xanthium spinosum*) or mildly poisonous, i.e. harmful species (*Carduus nutans, Cirsium arvense, Rumex crispus*).

CONCLUSION

Floristic composition of ass. *Trifolio-Agrostietum stolonifeae* stands in the Bačka region comprises 117 plant species. Based on the floristic analysis, *Ambrosia artemisiifolia*, *Bellis perennis, Carduus nutans, Cirsium arvense, Eupatorium cannabinum, Linaria vulgaris, Lotus corniculatus, Lythrum salicaria, Rumex crispus, Trifolium repens, Eleusine indica* and *Xanthium spinosum* were identified as invasive plants. The presence of invasive species in the stands of the analyzed vegetation, along with climate changes and intensive and inappropriate use of these areas, will inevitably lead to the degradation of biodiversity in the future. Therefore, continuous monitoring

of the invasive species proliferation in the ass. *Trifolio-Agrostietum stoloniferae* vegetation is necessary in order to preserve biodiversity and enhance pasture productivity.

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ИНВАЗИВНЕ ВРСТЕ У ФИТОЦЕНОЗИ *TRIFOLIO-AGROSTIETUM STOLONIFERAE* MARKOVIĆ 1973 У БАЧКОЈ

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РЕЗИМЕ: Инвазивне врсте су у вегетацији ливада и пашњака, поред климатских промена, неадекватног и интензивног коришћења, хидромелиоративних захвата, превођења ливада и пашњака у ораничне површине, значајан узрок деградације биодиверзитета. На подручју Бачке, на периодично плављеним пашњацима, се-

кундарно су развијене састојине ass. *Trifolio-Agrostietum stoloniferae* Марковић 1973. Флористички састав ових састојина чини 117 биљних врста, 94 на подручју Подунавља и 97 на подручју Потисја. Анализом флоре утврђено је да су *Ambrosia artemisiifolia*, *Bellis perennis, Carduus nutans, Cirsium arvense, Eupatorium cannabinum, Linaria vulgaris, Lotus corniculatus, Lythrum salicaria, Rumex crispus* и *Trifolium repens*, окарактерисане као инвазивне биљке за подручје Европе. Са Листе инвазивних врста за подручје Војводине присутне су *Ambrosia artemisiifolia, Eleusine indica* и *Xanthium spinosum*. *Lythrum salicaria* је окарактерисана као једна од 100 најопаснијих инвазивних врста на свету.

КЉУЧНЕ РЕЧИ: инвазивне врсте, пашњак, *Trifolio-Agrostietum stoloniferae*, вегетација.