INVASIVE NEOPHYTES IN NATURAL GRASSLANDS OF ROMANIA

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Abstract

In this paper, we have drawn up a list of neophytes which invade the primary and secondary grasslands of economic interest from Romania (pastures and hayfields), based on our own field works (2008-2016) and the literature. The list includes a number of 33 invasive neophytes, most of them native in North America and Asia. The harmful character of these species was discussed, related to their effect on the biodiversity and economical quality of the invaded grasslands. A large variation in the number of invasive neophytes in the analyzed grasslands have been registered, depending of the grassland type. The grasslands with the highest number of invasive neophytes were those from the orders Potentillo-Polygonetalia and Arrhenatheretalia, which are usually stronger disturbed by anthropogenic or natural factors. The less disturbed grasslands (from the orders Nardetalia and Caricetalia curvulae) were either invaded by a low number of neophytes or entirely free of neophytes.

Keywords: alien plants, biodiversity, natural grasslands, neophytes, plant invasion.

INTRODUCTION

Alien plants in a given area are those spontaneous and sub-spontaneous plants, native in other geographic regions, whose presence in that area is due to accidental or intentional introduction, as a result of human activity (RICHARDSON *et al.* 2000). The invasion of alien plants is globally recognized, as one of the greatest threats to natural biodiversity, economy and human health (VITOUSEK *et al.* 1997; PIMENTEL *et al.* 2000; MCNEELY 2001; HULME 2007).

Conventionally, in the botanical literature, alien plants are classified as neophytes (introduced after the year 1500), and archaeophytes (introduced before 1500) (PYŠEK *et al.* 2002).

Most plants introduced by man into a new area fail to survive too long in the new home if they (those deliberately introduced) are not under the direct human care. They can flourish and even reproduce occasionally in the new area, but cannot form long term self-sustaining populations. If anyone had the opportunity to register them, they only increase the list of *casual* alien plants (*sensu* RICHARDSON *et al.* 2000).

However, a small fraction of these immigrants, ca. 0.1%, according to some estimates

(WILLIAMSON and FITTER 1996) benefiting by the absence of competitors, by certain climatic conditions similar to those of their homelands, or by other favorable circumstances, after a longer or shorter stage of naturalization (a phase in which they gain the ability to reproduce themselves consistently in the place of introduction, without human intervention), can become *invasive*, *i.e*. able to spread to a considerable distance from the parent populations, conquering an increasingly large area. Some of the invasive alien plants, which have a demonstrated negative impact on natural ecosystems, were designated in the literature as *transformers* (RICHARDSON *et al.* 2000).

Research conducted in the last decades have shown a continuous enrichment of the neophyte flora of Romania. According to SÎRBU and OPREA (2011a), the number of alien species recorded in Romania amounts to 671, of which 593 neophytes (88,4%). Among them, over 100 species may be considered invasive. Given their high ability to spread in nature, these species have a real or potential capacity to cause negative impact on natural biodiversity, economy as well as on human health (SÎRBU and OPREA 2011a).

The invasion of neophytes especially affects habitats strongly determined or influenced by man, such as anthropogenic woodlands, ruderal habitats, arable lands or trampled areas, as we have shown for eastern Romania (Moldavia) (SÎRBU *et al*. 2012). However, some species can invade natural habitats, too, and in this study, we aimed to make a general assessment of the presence of the invasive neophytes in the permanent grasslands from Romania.

MATERIAL AND METHOD

Data were collected both by own field research carried out on alien plants (2008-2016) and by studying of an extensive floristic and phytosociological literature (for a complete list of references, see COLDEA 1997, 2012; SÎRBU and OPREA 2011a; CHIFU 2014). The invasive neophytes of the flora of Romania have been selected according to Anastasiu & Negrean (2009); SÎRBU and OPREA (2011a) and SÎRBU *et al.* (2012).

We have inventoried the invasive neophytes from the primary or secondary grasslands of economic interest from Romania (pastures and hayfields), which are dominated by perrenial herbs, belonging to the following classes and orders of vegetation (brief characterization, according to COLDEA 1997, 2012):
- Class *Festuco-Brometea* Br.-Bl. et R. Tx. ex Klika et Hadač 1944: ord. *Festucetalia valesiacae* Br.-Bl. et R. Tx. ex Br.-Bl. 1949 (continental, steppic grasslands, more or less xerophilous); ord. *Brometalia erecti*

Br.-Bl. 1936 (subatlantic grasslands, more or less thermophlous and meso-xerophilous, on calcareous substrates); ord. *Stipio pulcherrimae-Festucetalia pallentis* Pop 1968 (sub-continental xerophilous grasslands, on rendzinas, in hilly and mountainous floors);
- Class *Koelerio-Corynephoretea* Klika in Klika et Novák 1941: ord. *Festucetalia vaginatae* Soó 1957 (continental xerophilous grasslands on sandy soils);
- Class *Molinio-Arrhenatheretea* R. Tx. 1937: ord. *Molinietalia caeruleae* W. Koch 1926 (pasture and meadows on alluvial, moist or peaty soils); ord. *Arrhenatheretalia* R. Tx. 1931 (pasture and meadows on well-drained and fertile soils); ord. *Potentillo-Polygonetalia* R. Tx. 1947 (meso-higrophilous, mesotrophic grasslands on alluvial soils, tolerant halophilous, in intensively grazed habitats);
- Class *Festuco-Puccinellietea* Soó 1968: ord. *Puccinellietalia* Soó 1968 (Eurasian thermo-continental vegetation of saline meadows); ord. *Scorzonero-Juncetalia gerardii* Vicherek 1973 (continental moist halophytic meadows of south-east, central and eastern Europe);
- Class *Trifolio-Geranietea sanguinei* Th. Müller 1961: ord. *Origanetalia vulgaris* Th. Müller 1961 (secondary grasslands in contact with ± thermophilous and xero-mesophilous forests, on plains and hills);
- Class *Calluno-Ulicetea* Br.-Bl. et R. Tx. ex Klika et Hadač 1944: ord. *Nardetalia* Oberd. 1949 (secondary mountainous and subalpine mesophilous and acidophilous grasslands);
- Class *Juncetea trifidi* Klika et Hadač 1944: ord. *Caricetalia curvulae* Br.-Bl. 1926 (primary alpine and subalpine acidophilous grasslands).

RESULTS AND DISCUSSIONS

Neophytes invasive in the natural grasslands from Romania. A total number fo 33 invasive neophytes have been recorded in various types of natural grasslands from Romania (Tab. 1), *i.e.* (in an alphabetical order; Fig. 1 and 2): *Ailanthus altissima* (Mill.) Swingle, *Ambrosia artemisiifolia* L., *Amorpha fruticosa* L., *Armoracia rusticana* P.Gaertn., B.Mey. et Scherb., *Asclepias syriaca* L., *Chamomilla suaveolens* (Pursh) Rydb., *Conyza canadensis* (L.) Cronq., *Cuscuta campestris* Yunck., *Cytisus scoparius* (L.) Link., *Elaeagnus angustifolia* L., *Erigeron annuus* (L.) Pers. (ssp. *annuus* & *strigosus* (Muhl. ex Willd.) Wagenitz), *Helianthus tuberosus* L., *Juncus tenuis* Willd., *Lycium barbarum* L., *Medicago sativa* L., *M.* × *varia* Martyn, *Oxalis stricta* L., *Paspalum paspalodes* (Michx.) Scribn., *Picris echioides* L., *Reynoutria japonica* Houtt., *R.* × *bohemica* Chrtek &

Chrtková, *Robinia pseudacacia* L., *Rudbeckia laciniata* L., *Sisyrinchium montanum* Greene, *Solidago canadensis* L., *Solidago gigantea* Aiton, *Sorghum halepense* (L.) Pers., *Symphyotrichum ciliatum* (Ledeb.) G.L. Nesom, *S. lanceolatum* (Willd.) G.L. Nesom, *Trigonella caerulea* (L.) Ser., *Xanthium orientale* L. subsp. *italicum* (Moretti) Greuter, *Xanthium spinosum* L., *Zingeria pisidica* (Boiss.) Tutin.

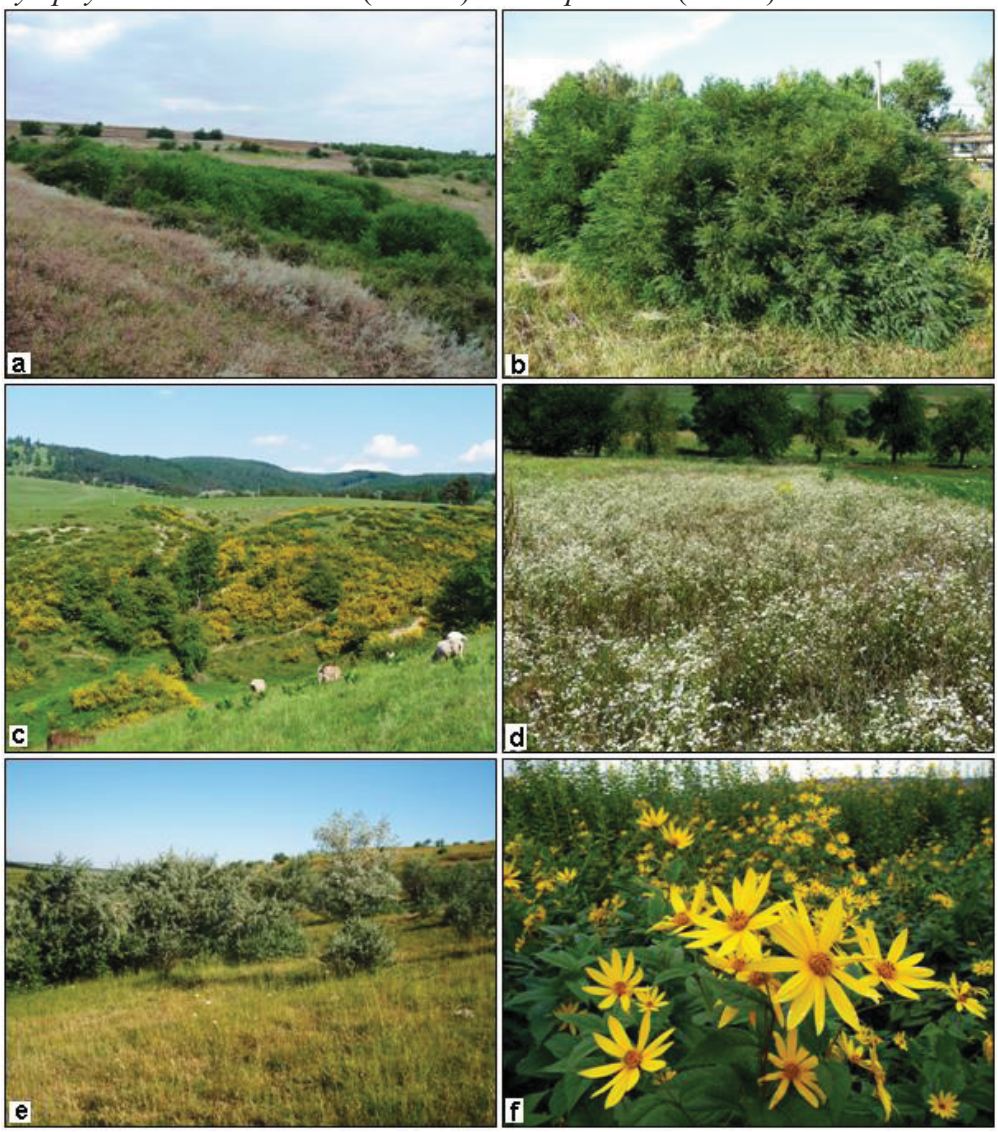

Fig. 1. Neophytes invasive in grasslands (1): a-*Ailanthus altissima* (Măluşteni, Vaslui county), b-*Amorpha fruticosa* (Holboca, Iaşi county), c-*Cytisus scoparius* (South of Moineşti, Bacău county), d-*Erigeron annuus* (Dobrovăţ, Iaşi county), e-*Elaeagnus angustifolia* (Crăieşti, Galaţi county), f-*Helianthus tuberosus* (Ibăneşti, Mureş county).

Among the invasive neophytes from grasslands, the most numerous belong to the families Asteraceae (40%) and Fabaceae (18%). Other 11 families are represented only by 1-3 species.

The majority of the invasive neophytes from grasslands are native in North America (52%) and Asia (21%). The other ones originate from the Mediterranean region, South America, tropical regions, or from the Central, South and South-East Europe. Two taxa resulted in Europe by intrageneric hybridization, having one or both parental species of exotic origin. Thus, *Medicago* × *varia* is a hybrid between *M. sativa* (a Central-Asian species) and *M. falcata* (an indigenous, Eurasian species) (MORARIU, in SĂVULESCU 1957), while *Reynoutria* × *bohemica* is a hybrid between *R. japonica* and *R. sachalinensis* (East Asian, both of them) (CHRTEK and CHRTKOVÁ 1983).

The inventoried invasive neophytes have been introduced in Romania either accidentally (xenophytes, 48.5%), or deliberately (hemerophytes, 51.5%). The great majority of hemerophytes were introduced as ornamental plants and only a few of them were introduced as fodder plants (*Medicago sativa, Trigonella caerulea*), as spicy (*Armoracia rusticana*) or for other uses.

Nearly half of these species (48.4%) are perennial herbaceous plants, geophytes or hemicryptophytes, in equal proportions. The other species are therophytes (30%), phanerophytes (18%) or hemi-therophytes (3%).

With few exceptions (*e.g. Medicago sativa*, *M.* × *varia*), the herbaceous perennial neophytes, as well as the ligneous ones (phanerophytes), have a great capacity for competition and vegetative propagation, by stolons, rhizomes, root suckers. In addition, most of the annual neophytes (*e.g. Conyza canadensis*, *Erigeron annuus*, *Ambrosia artemisiifolia* etc.) are very prolific, producing a large number of seeds (HOLM *et al.,* 1997; SÎRBU and OPREA, 2011a). Consequently, these neophytes often form monodominant stands which overwhelm and substitute the native vegetation of grasslands and other natural habitats. Such cases are fairly well documented in Romania, concerning species as follows: *Ailanthus altissima* (DIHORU and DONIŢĂ, 1970; SÎRBU and OPREA, 2011b), *Amorpha fruticosa* (ANASTASIU *et al.*, 2008; SĂRĂŢEANU *et al*., 2008; DOROFTEI, 2009; SÎRBU and OPREA, 2011a], *Cytisus scoparius* (SĂRĂŢEANU *et al.,* 2008), *Elaeagnus angustifolia* (SÎRBU and OPREA, 2011a), *Erigeron annuus* (Sîrbu et al. 2006; Sîrbu & Oprea 2011a), *Helianthus tuberosus* (POP *et al.*, 2002; MARIAN, 2002; KOVÁCS, 2004, 2006; BLAJ, 2006; SÎRBU and OPREA, 2007; SÎRBU and OPREA, 2011a), *Reynoutria* × *bohemica* (FENESI, 2004; KOVÁCS, 2004, 2006; SÎRBU and

OPREA, 2007, 2008, 2011a etc.), *R. japonica* (SZABÓ, 1971; KOVÁCS, 2004; FENESI, 2004; SÎRBU and OPREA, 2011a), *Robinia pseudacacia* (SÎRBU and OPREA, 2011a), *Rudbeckia laciniata* (SZABÓ, 1970; BUZ, 1999; KOVÁCS, 2004, 2006; DRĂGULESCU, 2004; SÎRBU and OPREA, 2011a], *Solidago canadensis* (KOVÁCS, 2004), *S. gigantea* (SÎRBU and OPREA, 2011a), *Xanthium orientale* subsp. *italicum* (BORZA, 1966; POP *et al.,* 2000; ANASTASIU *et al.*, 2008; SÎRBU and OPREA, 2011A etc.], *X. spinosum* (MORARIU, 1943; SÎRBU and OPREA, 2011A] etc.

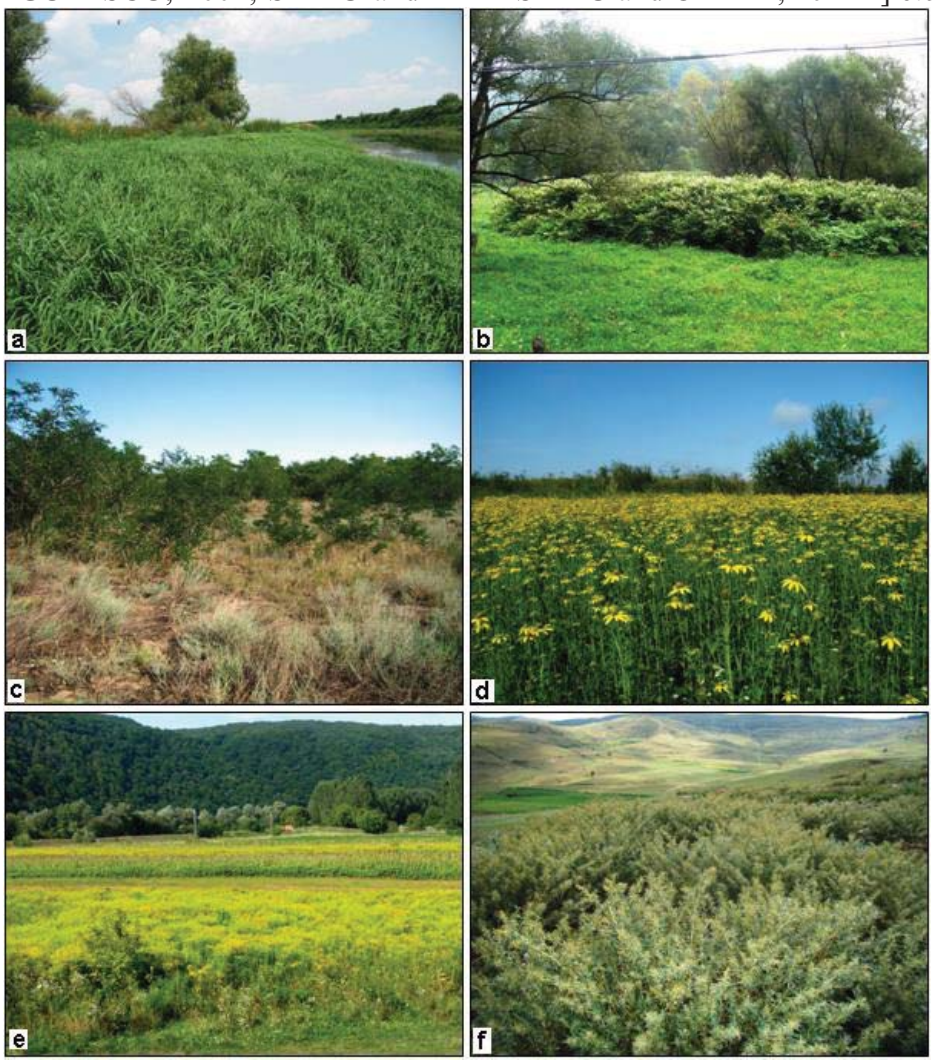

Fig. 2. Neophytes invasive in grasslands (2): a-*Paspalum paspalodes* (Mila 28, Tulcea county), b- *Reynoutria × bohemica* (Grinţieş, Neamţ county), c-*Robinia pseudacacia* (Hanu Conachi, Galaţi county), d-*Rudbeckia laciniata* (Avrig, Sibiu county), e-*Solidago canadensis* (Sovata, Mureş county), f-*Xanthium spinosum* (North of Berezeni, Vaslui county).

Besides competing with native species, the most neophytes listed above have also other features which recommend them as harmful weeds of grasslands. Approx. 25% of them are poisonous to animals, due to their content in different specific toxins, such as: ailanthone (*Ailanthus altissima*) (WITTENBERG, 2005; KOWARIK and SÄUMEL, 2007; UDWARDY, 2008), amorphigenin (*Amorpha fruticosa*) (SZIGETVÁRI and TÓTH, 2008), carboxyatractyloside (*Xanthium orientale* subsp. *italicum*, *X. spinosum*) (BÖSZÖRMÉNYI and BAGI, 2008), cardenolide (*Asclepias syriaca*) (BARKER *et al.*, 2006; BAGI, 2008], dhurrin (*Sorghum halepense*) (IONESCU-ŞIŞEŞTI 1958; BELTRANO and CALDIZ 1993; HOWARD, 2004), robinin (*Robinia pseudacacia*) (WITTENBERG, 2005; BAŞNOU, 2006), sparteine, isosparteine (*Cytisus scoparius*) (PETERSON and PRASAD, 1998). A number of 10 species (30% of the total list) release in the soil or air various allelopathic compounds which hinder the normal growth and development of the native plant species from grasslands: *Ailanthus altissima* (KOWARIK and SÄUMEL, 2007; UDWARDY, 2008), *Amorpha fruticosa* (SZIGETVÁRI and TÓTH, 2008), *Asclepias syriaca* (BAGI, 2008), *Conyza canadensis* (HOLM *et al.,* 1997), *Robinia pseudacacia* (BARTHA *et al*., 2008), *Solidago canadensis, S. gigantea* (WITTENBERG, 2005; BOTTA-DUKÁT annnd DANCZA, 2008), *Sorghum halepense* (BELTRANO and CALDIZ, 1993; HOWARD, 2004), *Xanthium orientale* subsp. *italicum*, *X. spinosum* (BÖSZÖRMÉNYI and BAGI, 2008). Some species release into the atmosphere, during the blooming period, a large amount of allergenic pollen: *Ailanthus altissima* (KOWARIK and SÄUMEL, 2007), *Xanthium* sp. (BÖSZÖRMÉNYI and BAGI, 2008), *Ambrosia artemisiifolia* (VICOL, 1971; BASSET and CROMPTON, 1975; MEDZIHRADSZKY and JÁRAI-KOMLÓDI, 1995; RYBNIČEK and JÄGER, 2001; IANOVICI and SÎRBU, 2007 etc.). Other species are undesirable in grasslands because they give a disagreeable taste to milk products if they are eaten by animals: *Armoracia rusticana*, *Ambrosia artemisiifolia* (FRANKTON and MULLIGAN, 1974). Fruits of *Xanthium* easy cling to sheep's wool, causing deterioration of its quality, while *Cuscuta campestris* is a widespread polyphagous parasite which cause the metabolic decline, the slowing down of the growth and development and finally the death of the host plants (BUIA, in SĂVULESCU, 1960). In addition, the symbiotic nodules on roots of neophytes from the *Fabaceae* and *Elaeagnaceae* families, by enriching the soil in nitrogen, facilitate the installation of nitrophilous weeds in the invaded habitats (KATZ and SHAFROTH, 2003).

Table 1

Invasive neophytes in the natural grasslands from Romania

Plant names	Invaded grasslands (orders of vegetation)											Fam.	Origin	Intr.	Life forms
	F.vl	St-F	Br.e	F.vg	Mo.c	Ar	P-P	Na	Or.v	Pu	S-J				
Ailanthus altissima	●	●	●	●			●		●			Sima	E As	h	Ph-Ψ
Ambrosia artemisiifolia				●			●					Aste	N Am	x	T
Amorpha fruticosa	●			●		●	●		●	●	●	Faba	N Am	h	Ph-ђ
Armoracia rusticana					●	●	●					Bras	SE Eur, W As	h	G
Asclepias syriaca	●					●			●			Ascl	N Am	h	G
Chamomilla suaveolens	●		●			●		●		●		Aste	N Am	x	T
Conyza canadensi	●	●	●	●	●	●	●		●			Aste	N Am	x	T
Cuscuta campestris	●	●	●	●		●	●		●	●		Cusc	N Am	x	T
Cytisus scoparius	●		●			●			●			Faba	C, S Eur	h	Ph-ђ
Elaeagnus angustifolia	●	●		●			●		●	●		Elae	As	h	Ph-ђ
Erigeron annuus	●	●	●	●	●	●	●		●			Aste	N Am	x	TH
Helianthus tuberosus						●	●		●			Aste	N Am	h	G
Juncus tenuis					●	●	●	●				Junc	N Am	x	G
Lycium barbarum	●											Sola	E As	h	Ph-ђ
Medicago sativa	●		●		●	●	●		●			Faba	C,W As	h	H-Ch
Medicago × varia	●					●	●			●		Faba	×	x	H
Oxalis stricta					●	●	●		●			Oxal	N Am	x	H
Paspalum paspalodes							●				●	Poac	Trop	x	H
Picris echioides	●	●							●			Aste	Md	x	T
Reynoutria × bohemica						●	●		●			Poly	×	h	G
Reynoutria japonica						●	●					Poly	E As	h	G
Robinia pseudacacia	●	●	●	●		●	●		●			Faba	N Am	h	Ph-Ψ
Rudbeckia laciniata					●	●	●					Aste	N Am	h	H
Sisyrinchium montanum					●	●	●					Irid	N Am	x	G
Solidago canadensis						●	●		●			Aste	N Am	h	H
Solidago gigantea						●	●					Aste	N Am	h	H
Sorghum halepense	●	●	●	●	●							Poac	S Md	x	G
Symphyotrichum ciliatum							●			●	●	Aste	N Am-As	x	T
Symphyotrichum lanceolatum					●	●	●			●		Aste	N Am	h	H
Trigonella caerulea	●				●	●	●			●	●	Faba	Md	h	T
Xanthium orientale subsp. *italicum*	●			●	●	●	●			●	●	Aste	N Am	x	T
Xanthium spinosum	●	●	●	●		●	●		●	●		Aste	S Am	x	T
Zingeria pisidica						●	●			●	●	Poac	W As	x	T

Orders of vegetation: **F.vl**-*Festucetalia valesiacae*; **St-F-***Stipio pulcherrimae-Festucetalia pallentis*; **Br.e-***Brometalia erecti*; **F.vg**-*Festucetalia vaginatae*; **Mo.c**-*Molinietalia caeruleae*; **Ar**-*Arrhenatheretalia*; **P-P**-*Potentillo-Polygonetalia*; **Na**-*Nardetalia*; **Or.v**-*Origanetalia vulgaris*; **Pu**-*Puccinellietalia*; **S-J**-*Scorzonero-Juncetalia gerardii* (see "Material and methods" for a short characterisation of the orders).

Fam. (plant families): **Ascl**-Asclepiadaceae, **Aste**-Asteraceae, **Bras**-Brassicaceae, **Cusc**-Cuscutaceae, **Elae**-Elaeagnaceae, **Faba**-Fabaceae, **Irid**-Iridaceae, **Junc**-Juncaceae, **Oxal**-Oxalidaceae, **Poac**-Poaceae, **Poly**-Polygonaceae, **Sima**-Simaraoubaceae, **Sola**-Solanaceae.
Geographic origin: **Am**-America, **As**-Asia, **Eur**-Europe, **Md**-Mediterranean region, **Trop**-Tropical regions (N-North, S-South, E-East, W-West, C-Central), × - species of hybrid origin.
Intr. (introduction mode): **h**-hemerophytes (introduced deliberately by man, for various uses, subsequently becoming invasive), **x**-xenophytes (introduced accidentally).
Life forms: Ch-chamaephytes, **G**-geophytes, **H**-hemicryptophytes, **Ph**-phanerophytes (Ψ-trees, ђ shrubs), **T**-therophytes, **TH**-hemiterophytes.

Among the listed neophytes, only two species (*Medicago sativa* and *M. × varia*) are valuable fodder plants (KOVÁCS, 1979). To these, one could add *Trigonella caerulea, Cytisus scoparius* and *Helianthus tuberosus*, the latter two being more important for the wild fauna (deers, rabbits, wild boars). In the category of useful plants some species can also be included as medicinal (*Robinia pseudacacia*, *Lycium barbarum*, *Chamomilla suaveolens*) or melliferous plants (*Asclepias syriaca, Robinia pseudacacia, Helianthus tuberosus, Rudbeckia laciniata* etc.). However, one should not overlook the negative effect on natural biodiversity of melliferous neophytes by their competition with native flora to attract pollinators (WIESELER, 2005; JAKOBSSON *et al*., 2008).

Types of grasslands invaded by neophytes in Romania. The natural grasslands invaded by the listed neophytes belong to a number of 10 orders and 7 classes of vegetation (Tab. 1).

The grasslands with the greatest number of invasive neophytes were those from the orders *Potentillo-Polygonetalia* (27 species), *Arrhenatheretalia* (25 species), *Festucetalia valesiacae* (18 species), *Origanetalia vulgaris* (16 species), *Molinietalia caeruleae* (12 species), *Festucetalia vaginatae*, *Puccinellietalia* (11 species, each). These were followed by the grasslands from the orders *Brometalia erecti*, *Stipio pulcherrimae- Festucetalia pallentis* and *Scorzonero-Juncetalia gerardii* (between 6 and 10 species). The secondary mountainous and subalpine mesophilous and acidophilous grasslands from the order *Nardetalia* had in their plant composition only 2 species of neophytes (*Chamomilla suaveolens* and *Juncus tenuis*). The only types of grasslands, among those investigated by us, which were completely free of invasive neophytes were those from the order *Caricetalia curvulae* (the class *Juncetea trifidi*), *i.e*. primary alpine and subalpine acidophile grasslands. We have registered, therefore, a large variation in the number of invasive neophytes in the analyzed grasslands (between 0 and 27 species). The presence of large numbers of neophytes in some types of grasslands can be positively correlated with their high degree of anthropogenic or natural disturbance (by overgrazing, soil mobilization;

respectively periodical floodings, soil-scratching by animals etc.), as already demonstrated in various studies (HOBBS and HUENNEKE, 1992; ALPERT *et al*., 2000; STOHLGREN, 2002; HIERRO *et al.,* 2006; SÎRBU *et al.,* 2012). By contrast, the less disturbed grasslands, such as those of the orders *Nardetalia* and *Caricetalia curvulae*, were either very little invaded or entirely free of neophytes. The climatic conditions beyond ecological tolerance of neophytes in alpine and subalpine grasslands could also be important as a barrier against invaders (BECKER *et al.*, 2005; CHYTRÝ *et al.,* 2005).

CONCLUSIONS

A total number fo 33 invasive neophytes have been identified in various types of natural grasslands from Romania, mostly native in North America and Asia.

The great majority of perennials and ligneous neophytes have a great capacity for competition and vegetative propagation, being able to form monodominant stands which overwhelm native vegetation of grasslands. In addition, the most neophytes from grasslands have also other features which recommend them as harmful weeds, such as: toxicity, allelopathic effects, allergenic pollen, capacity to harm the quality of livestock products, to change the soil chemistry etc.

The grasslands with most invasive neophytes were those from the orders *Potentillo-Polygonetalia* (meso-higrophilous, mesotrophic grasslands on alluvial soils, tolerant halophilous, in intensively grazed habitats) and *Arrhenatheretalia* (pasture and meadows on well-drained and fertile soils), while the alpine and subalpine acidophilous grasslands (the orders *Nardetalia* and *Caricetalia curvulae*) were either invaded by a small number of neophytes or entirely free of neophytes.

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