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Invasive and expansive plant species in Slovakian agrocoenoses

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Abstract: The distribution of invasive alien and expansive native vascular plant species in plant communities growing on fields in Slovakia was studied. Arable fields (cereals, perennial fodder crops, root, and stubbles) and 1-2-year abandoned fields were evaluated. The study was based on phytosociological data consisting of 486 relevés recorded in 2002-2008, from various parts of Slovakia. In the group of 371 vascular plant taxa recorded in the segetal communities (so-called weeds), 56 taxa are invasive or expansive species, representing 15% of total taxa. Among them, 21 taxa are invasive (10 neophytes and 11 archaeophytes), 10 are potentially invasive, 4 are frequently escaping from cultivation, 6 are occasionally escaping from cultivation, 5 species are naturalized, 8 are expansive native taxa, and 2 are data-deficient. The most frequent invasive or expansive weed species in the studied agrocoenoses were: *Tripleurospermum perforatum*, *Cirsium arvense*, and *Veronica persica*. Recorded species belong to 19 families, mostly to the Asteraceae, Chenopodiaceae, and Poaceae.

Key words: alien species, invasive plants, expansive plants, vascular plants, arable land, Slovakia

1. Introduction

Biological invasions are a challenging topic, frequently addressed by researchers in the last decades. Invasive species play an important role in local floras and faunas, because of their increasing number and abundance. Disturbed areas, which are strongly affected by man, are the biotopes particularly prone to plant invasions (Török *et al*. 2003; Chytrý *et al*. 2005; Rabitsch & Essl 2006).

Although arable land can be a major source for the spread of invasive plants, there have been no studies on the occurrence of invasive species on arable fields in Slovakia so far. Pyšek *et al*. (2005) studied alien plants in weed communities in the Czech Republic.

The aims of this study were: (*i*) to explore the distribution of invasive alien and expansive native vascular plant species in agrocoenoses in Slovakia; and (*ii*) to evaluate their occurrence in various field types.

2. Material and methods

The study is based on our own phytosociological data, consisting of 486 relevés from various parts of Slovakia, recorded in 2002-2008 (Fig. 1). Phytocoenoses were analysed in the field according to the methods of Zürich-Montpelliér school (Braun-Blanquet 1964), and the modified 9-degree scale of abundance and dominance by Barkman *et al*. (1964) was employed. Two species, *Abutilon theophrastii* and *Silybum marianum*, were observed only outside the relevé plots, but they were recorded as occurring on arable land as well. Classification of the recorded invasive plants followed Gojdičová *et al*. (2002) who classified 616 taxa into 8

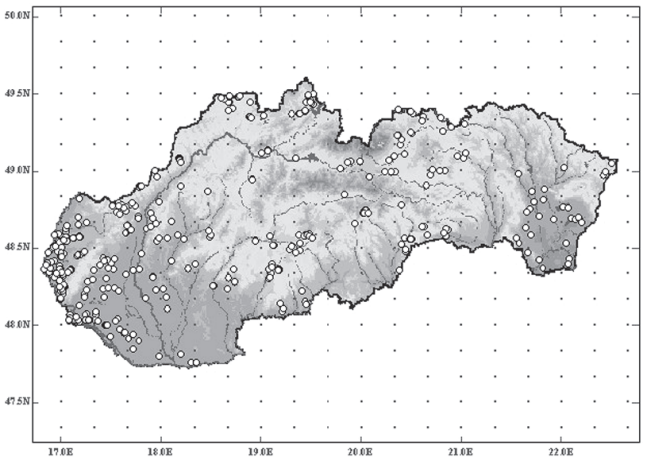

Fig. 1. Distribution of relevés recorded in arable land in Slovakia in 2002-2008

Table 1. Categorization of invasive and expansive plant species recorded in agrocoenoses in Slovakia (according to Gojdičová *et al*. 2002)

Number and category of invasive and expansive plant species		Number of species	%	List of species
1	Invasive alien taxa:			
1a	Neophytes	10	17.9	*Ambrosia artemisiifolia, Aster lanceolatus, Bidens frondosa, Conyza canadensis, Fallopia ×bohemica, Galinsoga parviflora, G. urticifolia, Negundo aceroides, Solidago gigantea, Stenactis annua*
1b	Archaeophytes	11	19.7	*Apera spica-venti, Bromus sterilis, Cardaria draba, Chenopodium ficifolium, C. pedunculare, Cichorium intybus, Cirsium vulgare, Conium maculatum, Melilotus officinalis, Tanacetum vulgare, Tripleurospermum perforatum*
2	Potentially (regionally) invasive taxa	10	17.9	*Abutilon theophrasti, Amaranthus powellii, A. retroflexus, Bassia scoparia, Cannabis ruderalis, Chenopodium strictum, Datura stramonium, Erucastrum gallicum, Matricaria discoidea, Xanthoxalis stricta*
3	Taxa frequently escaping from cultivation	4	7.1	*Anethum graveolens, Brassica napus* subsp. *napus, Helianthus annuus, Silybum marianum*
4	Taxa occasionally escaping from cultivation	6	10.7	*Brassica oleracea, Cucurbita pepo, Lolium multiflorum, Phacelia tanacetifolia, Solanum tuberosum, Thladiantha dubia*
5	Accidentally introduced taxa	-	-	-
6	Naturalized taxa	5	8.9	*Amaranthus albus, A. blitoides, Anagallis foemina, Trifolium hybridum* subsp. *hybridum, Veronica persica*
7	Data-deficient taxa	2	3.6	*Medicago sativa, Xanthium albinum*
8	Expansive native taxa	8	14.2	*Arrhenatherum elatius, Artemisia vulgaris, Atriplex patula, Bidens tripartita, Cirsium arvense, Pastinaca sativa, Phleum pratense, Ranunculus repens*
	Total	56	100.0	

categories (see Table 1). *Bassia scoparia*, *Stenactis annua* and *Xanthium albinum* were only determined to the species level (in contrast to the subspecies level classification by Gojdičová *et al*. 2002). *Stenactis annua* was classified into category 1a, because *S. a*. subsp. *septentrionalis* is probably the most abundant subspecies in Slovakia (Dostál & Červenka 1992). The same authors consider *Xanthium albinum* subsp. *albinum* to be the most abundant subspecies in Slovakia. However, the presence of this subspecies has not been confirmed in Austria yet, according to Fischer *et al*. (2008). Preliminarily we classified this species into category 7 (as *X. a*. subsp. *albinum*), but the determination requires a further study. Both subspecies of *Bassia scoparia* are classified into category 2 (Gojdičová *et al*. 2002), so the classification of the species was unequivocal.

Taxonomic classification of the plant families followed Marhold (1998). Data on life forms were taken from Kubát (2002). Species exhibiting more than one life form were considered as representatives of both of them.

The studied fields were divided into 5 types, according to crop type and agricultural management (Table 2): cereals (including wheat, barley, rye, oat, but also flax, rape, and crop mixtures), root crops (including potatoes, maize, sunflower, beet and vegetables), stubbles (after harvesting the cereals), perennial fodder crops (including lucerne and clover), and 1-2-year abandoned fields. Numbers of relevés from each field type are given in Table 2.

3. Results

In the total of 486 relevés from arable land in Slovakia, we recorded 371 vascular plant taxa, growing as weeds in crop fields. Among them, 56 taxa (i.e. 15% of total taxa) are included in the list of alien, invasive alien and expansive native vascular plant species of Slovakia by Gojdičová *et al*. (2002). Their classification into categories according to those authors is presented in Table 1. Most of these taxa are classified as invasive (21 species, i.e. 38% of this group): 10 neophytes and 11 archaeophytes. Less numerous are potentially invasive taxa, expansive native taxa, taxa occasionally escaping from cultivation, naturalized taxa, taxa frequently escaping from cultivation, and data-deficient taxa. We have not recorded any species from the category of accidentally introduced taxa (Table 1).

The recorded invasive and expansive species belong to 19 plant families (Fig. 2). The most numerous were species from the families Asteraceae (18 spp.), Chenopodiaceae (5 spp.) and Poaceae (5 spp.). The family Hydrophyllaceae (represented by *Phacelia tanacetifolia*) is an exotic family, without any native species in the Slovak flora.

Among Raunkiaer's life forms, therophytes dominated with the proportion of 59% (Fig. 3). They were followed by hemicryptophytes (31%), geophytes (6%), chamaephytes and phanerophytes with 2%.

Distribution of the recorded species in the various types of biotopes was apparently not random: 42 taxa were recorded in cereal fields, 39 in potato fields, etc., 33 on stubbles, 20 in perennial fodder crop fields, and 11 taxa on young abandoned fields. Some species preferably grow in a certain type of biotope (Table 2). *Apera spica-venti* and *Xanthoxalis stricta* are typical for cereal fields, while *Amaranthus powellii*, *A. retroflexus*, *Galinsoga parviflora* and *G. urticifolia* for the rot crops *Anagallis foemina*, *Amaranthus retroflexus*, *Atriplex*

Table 2. Frequency and abundance of invasive and expansive plant species in the studied field types

Taxon	Cover of species	Field type (number of relevés)											
		Cereals (263)		Root crops (117)		Stubbles (59)		Perennial fodder (30)		Abandoned fields (17)		Total (486)	
		N	%	N	%	N	%	N	%	N	%	N	%
*Abutilon theophrasti**	-	-	-	-	-	1	-	-	-	-	-	1	-
Amaranthus albus	+ (+, 2b)	-	-	-	-	2	3.0	-	-	-	-	2	1.0
Amaranthus blitoides	+ (+, 1)	-	-	3	3.0	-	-	1	3.0	-	-	4	1.0
Amaranthus powellii	+ (+, 3)	3	1.0	17	15.0	6	10.0	1	3.0	-	-	27	6.0
Amaranthus retroflexus	+ (r, 5)	3	1.0	23	20.0	12	20.0	1	3.0	-	-	39	8.0
Ambrosia artemisiifolia	+ (r, 5)	10	4.0	3	3.0	6	10.0	-	-	-	-	19	4.0
Anagallis foemina	+ (r, 1)	6	2.0	-	-	16	27.0	-	-	1	6.0	23	5.0
Anethum graveolens	r (r, +)	1	1.0	1	1.0	-	-	-	-	-	-	2	1.0
Apera spica-venti	1 (r, 5)	140	53.0	4	3.0	2	3.0	4	13.0	10	59.0	160	33.0
Arrhenatherum elatius	+	2	1.0	-	-	1	2.0	1	3.0	-	-	4	1.0
Artemisia vulgaris	+ (r, 5)	44	17.0	21	18.0	17	29.0	6	20.0	2	12.0	90	19.0
Aster lanceolatus	+ (r, 2a)	3	1.0	1	1.0	3	5.0	1	3.0	-	-	8	2.0
Atriplex patula	+ (r, 2a)	12	5.0	17	15.0	15	25.0	1	3.0	2	12.0	47	10.0
Bassia scoparia	r	-	-	-	-	1	2.0	-	-	-	-	1	1.0
Bidens frondosa	+	1	1.0	1	1.0	-	-	-	-	-	-	2	1.0
Bidens tripartita	r	-	-	1	1.0	-	-	-	-	-	-	1	1.0
Brassica napus subsp. *napus*	+ (r, 2a)	21	8.0	8	7.0	8	14.0	1	3.0	2	12.0	40	8.0
Brassica oleracea	+	-	-	1	1.0	-	-	-	-	-	-	1	1.0
Bromus sterilis	+	4	2.0	-	-	-	-	1	3.0	-	-	5	1.0
Cannabis ruderalis	1 (r, 3)	1	1.0	1	1.0	1	2.0	-	-	-	-	3	1.0
Cardaria draba	+ (+, 1)	3	1.0	-	-	2	3.0	-	-	-	-	5	1.0
Chenopodium ficifolium	+ (+, 2a)	1	1.0	2	2.0	1	2.0	-	-	-	-	4	1.0
Chenopodium pedunculare	+ (+, 2b)	-	-	2	2.0	4	7.0	-	-	-	-	6	1.0
Chenopodium strictum	+	-	-	1	1.0	1	2.0	-	-	-	-	2	1.0
Cichorium intybus	+	-	-	3	3.0	-	-	-	-	-	-	3	1.0
Cirsium arvense	+ (+, 3)	176	67.0	96	82.0	47	80.0	14	47.0	7	41.0	340	70.0
Cirsium vulgare	r	-	-	1	1.0	-	-	-	-	-	-	1	1.0
Conium maculatum	+ (+, 2b)	2	1.0	-	-	2	3.0	2	7.0	-	-	6	1.0
Conyza canadensis	+ (r, 5)	34	13.0	3	3.0	33	56.0	7	23.0	7	41.0	84	17.0
Cucurbita pepo	+ (+, 1)	-	-	2	2.0	-	-	-	-	-	-	2	1.0
Datura stramonium	2a (1, 5)	-	-	3	3.0	2	3.0	-	-	-	-	5	1.0
Erucastrum gallicum	+	-	-	-	-	1	2.0	1	3.0	-	-	2	1.0
Fallopia ×bohemica	3	1	1.0	-	-	-	-	-	-	-	-	1	1.0
Galinsoga parviflora	2a (r, 5)	13	5.0	47	40.0	8	14.0	-	-	1	6.0	69	14.0
Galinsoga urticifolia	1 (+, 5)	18	7.0	38	32.0	2	3.0	-	-	-	-	58	12.0
Helianthus annuus	+ (r, 3)	5	2.0	3	3.0	4	7.0	-	-	-	-	12	2.0
Lolium multiflorum	+	2	1.0	1	1.0	-	-	-	-	-	-	3	1.0
Matricaria discoidea	+ (+, 2a)	17	6.0	15	13.0	-	-	-	-	-	-	32	7.0
Medicago sativa	+ (r, 2a)	6	2.0	2	2.0	-	-	-	-	-	-	8	2.0
Melilotus officinalis	+ (r, 1)	4	2.0	-	-	-	-	-	-	-	-	4	1.0
Negundo aceroides (=*Acer negundo*)	r	1	1.0	1	1.0	1	2.0	-	-	-	-	3	1.0
Pastinaca sativa	+	1	1.0	-	-	-	-	-	-	-	-	1	1.0
Phacelia tanacetifolia	r	1	1.0	-	-	-	-	-	-	-	-	1	1.0
Phleum pratense	+	4	2.0	-	-	-	-	-	-	-	-	4	1.0
Ranunculus repens	+ (r, 1)	18	7.0	7	6.0	-	-	2	7.0	-	-	27	6.0
*Silybum marianum**	-	1	-	-	-	-	-	-	-	-	-	1	-
Solanum tuberosum	+ (r, 1)	24	9.0	-	-	-	-	-	-	-	-	24	5.0
Solidago gigantea	+ (r, 4)	1	1.0	3	3.0	1	2.0	2	7.0	-	-	7	1.0
Stenactis annua	+ (r, 2a)	4	2.0	-	-	2	3.0	8	27.0	-	-	14	3.0
Tanacetum vulgare	+ (r, 2a)	10	4.0	2	2.0	4	7.0	-	-	-	-	16	3.0
Thladiantha dubia	+ (+, 5)	-	-	2	2.0	-	-	-	-	-	-	2	1.0
Trifolium hybridum subsp. *hybridum*	+ (+, 2a)	9	3.0	3	3.0	-	-	-	-	-	-	12	2.0
Tripleurospermum perforatum	+ (r, 5)	210	80.0	61	52.0	42	71.0	25	83.0	12	71.0	350	72.0
Veronica persica	+ (r, 4)	125	48.0	55	47.0	25	42.0	17	57.0	3	18.0	225	46.0
Xanthium albinum	+ (+, 1)	2	1.0	3	3.0	-	-	-	-	-	-	5	1.0
Xanthoxalis stricta (=*Oxalis stricta*)	+ (r, 2b)	49	19.0	12	10.0	19	32.0	1	3.0	1	6.0	82	17.0

Explanations: For each species, its cover is given, expressed as the median (with minimum and maximum values in brackets), and its frequency in various types of biotopes: number of relevés (and percentages) in which the species was recorded. Species marked with asterisk (*) were recorded outside the relevé plots, and therefore do not have a value of abundance and frequency

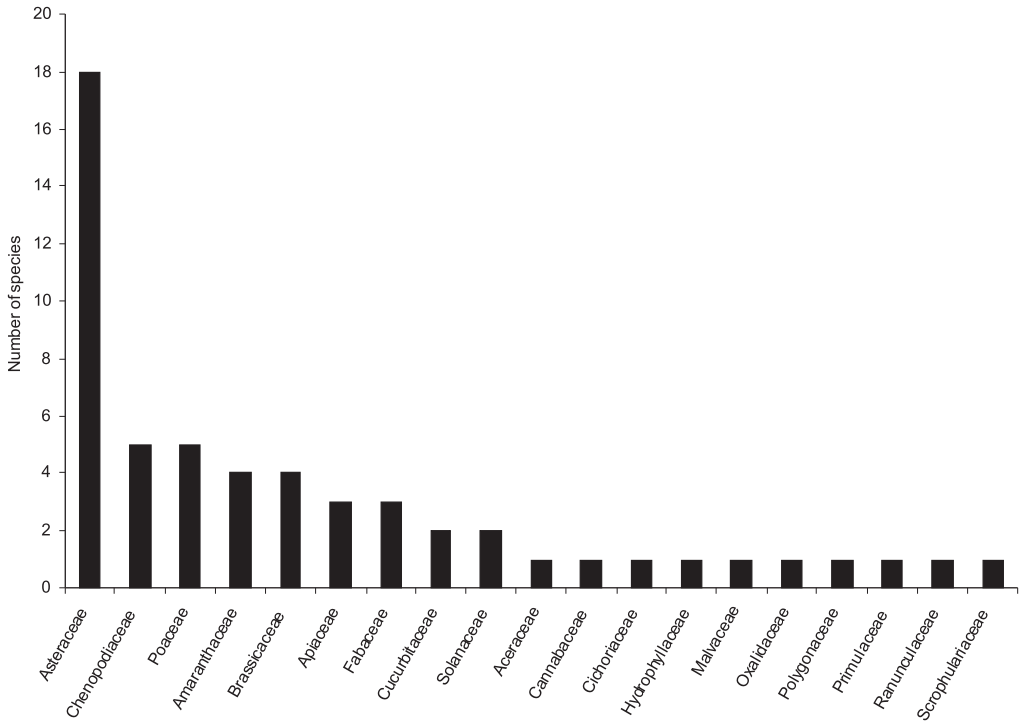

Fig. 2. The taxonomic distribution of the recorded invasive and expansive species in agrocoenoses in Slovakia according to plant families

patula, *Conyza canadensis* and *Xanthoxalis stricta* are typically found in stubbles; *Conyza canadensis* and *Stenactis annua* in perennial fodder crop fields; whereas *Apera spica-venti* and *Conyza canadensis* in young abandoned fields. Some species occurred in all field types: *Apera spica-venti*, *Artemisia vulgaris*, *Atriplex patula*, *Brassica napus* subsp. *napus*, *Cirsium arvense*, *Conyza canadensis*, *Tripleurospermum perforatum*, *Veronica persica*, and *Xanthoxalis stricta*. The most frequent species in all relevés were: the invasive archaeophyte *Tripleurospermum perforatum* (72%), the expansive native *Cirsium arvense* (70%) and the naturalized *Veronica persica* (46%).

Invasiveness of individual species is determined not only by their frequency but also by their abundance.

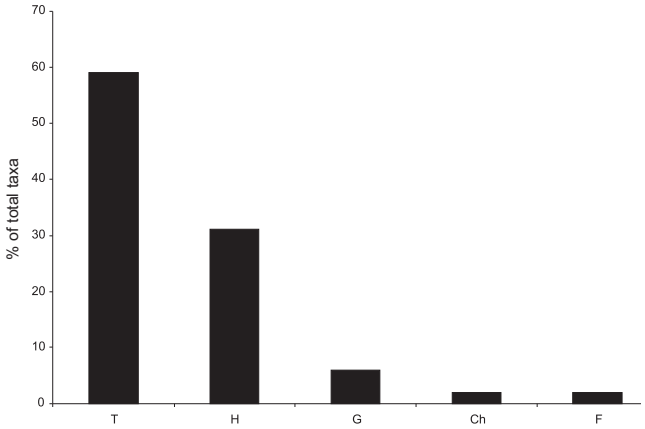

Fig. 3. Distribution of Raunkiaer's life forms among the recorded invasive alien and expansive species in agrocoenoses in Slovakia
Explanations: T – therophytes, H – hemicryptophytes, G – geophytes, Ch – chamaephytes, F – phanerophytes

We considered a species to be invasive or expansive if it occurred at least in 2% of all relevés with an abundance higher than 25% (i.e. cover values 3, 4 and 5 given in Table 2). Thus, the following species were recorded as invasive or expansive in the studied fields: *Apera spica-venti*, *Galinsoga parviflora*, *G. urticifolia*, *Tripleurospermum perforatum*, and *Veronica persica*.

4. Discussion

The most numerous invasive species were those from the family Asteraceae. A similar situation has been found also in other local or regional studies in Central Europe: the Asteraceae were reported as the most frequently represented family in alien floras (Pyšek *et al.* 2002; Rabitsch & Essl 2006; Urbisz & Urbisz 2008). On the global scale, this family ranks second (after Poaceae) in the percentage representation in alien floras (Pyšek 1997). The invasion success of Asteraceae has been thoroughly discussed by Pyšek (1997).

The occurrence of some alien species on arable lands is probably only casual and temporary. This apparently applies to *Bassia scoparia*, *Brassica oleracea*, *Pastinaca sativa*, *Phacelia tanacetifolia*, *Silybum marianum*. Some species (e.g. *Anagallis foemina*, *Veronica persica*) do not threaten the planted crops, in spite of their high frequency and sometimes also high abundance. They are low annuals. On the other hand, *Amaranthus retroflexus*, *Cirsium arvense*, *Datura stramonium*, and *Tripleurospermum perforatum* are considered as very dangerous weeds for crops (Líška & Hunková 2002). They often form dense populations of tall plants. They may even

pose a threat to agroarchaeophytes and decrease their diversity, as they occupy niches of segetal species. *Fallopia ×bohemica* and *Solidago gigantea* are still rare in agrocoenoses, but they have a high invasive potential for spreading to other sites because of their effective vegetative reproduction (Terpó 1997). Some other species can also be of major concern for humans: *Ambrosia artemisiifolia* is a serious allergenic plant, while *Datura stramonium* (recorded on fields also by Hrivnák & Cvachová 1997) and *Conium maculatum* are poisonous to both humans and animals (Deyl 1964; Líška & Hunková 2002).

Interestingly, we observed among the recorded invasive species a rather high proportion of hemicryptophytes (31%), although segetal communities are considered to consist mainly of annual species, i.e. therophytes (Jarolímek *et al*. 1997). Most of the invasive hemicryptophytes were from the families Asteraceae, Poaceae and Fabaceae, and they occurred in all field types.

The list of invasive and expansive plant species occurring in agrocoenoses in Slovakia presented in this paper is presumably not final yet. There are still missing data from some regions of Slovakia where agriculture is also well-developed, mainly in southern Slovakia (see Fig. 1). Various types of field biotopes have not been covered equally, and this fact also may have biased the data on species occurrence (Table 2). Frequency and also abundance of some species may therefore be in fact higher than presented here.

Abutilon theophrasti is one of the most frequent and abundant alien weeds of arable land in Hungary (Török *et al*. 2003; see also Terpó 1997). Therefore, it may be assumed that it is quite common also in Slovakia, especially in the areas near Hungarian borders. Jehlík *et al*. (1998) indeed recorded this species on fields in southern Slovakia (mainly in the Podunajská Lowland), where it has an ecological optimum in root crop fields. We also recorded the species from this area, but only in one locality on a stubble (Table 2). It remains to be explored if *Abutilon theophrasti* is more frequently represented on arable land in Slovakia than observed here.

Similarly, also the thermophilous alien grass *Sorghum halepense* is one of the most frequent and abundant alien weeds of arable land in Hungary (Török *et al*. 2003). Although Jehlík *et al*. (1998) mentioned several localities from southern Slovakia, where the species grew as a weed on arable land (especially in maize fields), we have not recorded it in the studied habitats. Still, its occurrence cannot be excluded, and further field research is needed.

There were some other species recorded in the research plots (e.g. *Anthemis arvensis*, *Convolvulus arvensis* and *Chenopodium polyspermum*), which Pyšek *et al*. (2002) classify as naturalized in the Czech Republic, but they are not included in the list by Gojdičová *et al*. (2002).

Further studies devoted to the occurrence of invasive alien and expansive plant species in arable land are necessary, to record these species and to track the infiltration of new invasive species into these biotopes.

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