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THE MELLIFEROUS POTENTIAL OF APIFLORA OF SOUTHWESTERN VOJVODINA (SERBIA)

Marina P. Mačukanović-Jocić[1,*] and Snežana V. Jarić[2]

[1] *Department of Agrobotany, Faculty of Agriculture, University of Belgrade*, Zemun, Belgrade, Serbia

[2] *Department of Ecology, Institute for Biological Research "Siniša Stanković", University of Belgrade*, Belgrade, Serbia

*__Corresponding author__: marmajo@agrif.bg.ac.rs

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Abstract: The individual and community-level melliferous potential of apiflora was evaluated in southwestern Vojvodina in order to assess its significance and contribution to the bee pasture. Seven plant communities belonging to ruderal, segetal and floodplain type of vegetation, with a total of 279 plant species were registered. Apifloristic and phytocoenological investigations included the determination and analysis of honey plants using the following parameters: total number, percentage, abundance and frequency of these species in the communities, as well as their intensity of pollen and nectar production. The coenotic coefficient of melliferousness (CCm) indicating the melliferous potential of each community, was calculated based on the above parameters. Although the greatest number of melliferous species was found in the ass. *Chenopodio-Ambrosietum artemisiifoliae* (132), the highest percentage (80%) of them was registered in the ass. *Consolido-Polygonetum avicularis*. Considering the coefficients of nectar and pollen production, the most valuable honey plants commonly present in the majority of communities were: *Cirsium arvense, Rubus caesius, Lythrum salicaria, Daucus carota, Trifolium pratense, Dipsacus laciniatus, Medicago sativa, Asclepias syriaca, Cichorium intybus* and *Taraxacum officinale*. The low abundance and frequency of melliferous species within the *Consolido-Polygonetum avicularis, Polygonetum convolvulo-avicularis* and *Populetum nigrae-albae* communities indicated their poor contribution to the bee pasture. Within ruderal vegetation, the highest CCm was registered in *Amorpho-Typhaetum,* providing, theoretically, the richest food resource for the honeybees in the investigated area.

Key words: melliferous potential; honeybee; plant community; pollen; nectar

INTRODUCTION

Serbia is known for its rich and diverse flora, however, opportunities for profitable beekeeping are limited because in some types of vegetation only a small number of good melliferous plants exist or the climate conditions are unfavorable. Bees search for melliferous plants in forest, meadow, ruderal and swamp vegetation, but also in agrophytocoenoses such as orchards, vineyards, crops of oilseed rape, sunflower and alfalfa or in plantations with medicinal and aromatic plants.

Weed flora and vegetation have been the subject of numerous studies from different aspects, including weeds in arable land in Europe and worldwide (Bourdôt et al., 1998; Kireç 1999; Lososova et al., 2004). In Serbia, over the years, many investigations focused on segetal weeds (Gajić, 1955; Kovačević, 1957, 1961). A detailed review of weed communities with their syntaxonomic affiliation, as well as an inventory of all weed species in the territory of the former Yugoslavia, especially among arable crops, was reported by Kojić (1972). During the 20th and at the beginning of the 21st century, a significant contribution was made in the investigation of weed flora and vegetation, especially of cereal crops and orchards (Stepić, 1984; Stefanović, 1987; Crnčević, 1994; Ajder, 1996; Kojić et al., 2004; Vrbničanin et al., 2008; Jarić, 2009).

Earlier apifloristic studies were mostly focused on the nectar and pollen potential of individual plant species (Ricciardelli D'Albore and Intoppa, 2000; Mačukanović-Jocić et al., 2008; Mačukanović-Jocić et al., 2011), or the melliferous potential of meadow and forest plant communities as well as agrophytocoenoses (Blaženčić et al., 1994; Grabeljšek, 1996; Mačukanović and Grabeljšek, 1996; Jarić, 2009; Jarić et al., 2013; Nedić et al., 2013). Considering that weeds have been studied poorly so far as regards bee forage, our research, with its focus on melliferous plants in natural and anthropogenically changed phytocoenoses, represents an extension of previously investigated Serbian apiflora.

In the study region, flatlands dominated by arable land prevail, so that huge areas are under crops growing in monocultures, and except for the flowering period of the main bee pastures (oilseed rape, fruit pasture, black locust, sunflower), a large number of weed species are available to honeybees. The individual and community-level melliferous potential of apiflora belonging to ruderal, segetal and floodplain vegetation was evaluated in southwestern Vojvodina (Serbia) in order to establish its significance and contribution to the bee pasture. The current investigation also aimed to establish the plant community that was the richest food resource for honeybees. The theoretical evaluation of the melliferous potential is expected to have a practical application and to contribute to the improvement of beekeeping.

MATERIALS AND METHODS

Study area

The research area is situated on the southern edge of the Pannonian plain (northwestern Serbia), along the Sava River (44° 39` - 44° 54` N, 21° 38` - 21° 51` E), below the altitude of 100 m. According to the Ecological Atlas of Belgrade (2002), this area is classified in topoclimatic zone 3, which is characterized by an average annual rainfall of 610 mm and mean annual temperature of 11.5°C. The average monthly rainfall is maximum in June (94.6 mm), and the minimum is in February (32.7 mm). The 'košava' is the dominant southeastern wind that blows throughout the year. In this part of Serbia, anthropogenic impacts are highly expressed and manifested through deforestation and cultivation. In addition to human influence, frequent floods cause field colonization by weeds, which include numerous allochthonous species.

Floristic-phytocoenological research

Phytocoenological analysis included identification of the plant communities in the research area as well as examination of the abundance and frequency of all melliferous species grown within them. Also, the flowering phenology of the melliferous species was monitored during the whole vegetation period. Plant determination was performed according to Tutin (1964-1980) and Josifović (1970-1980). The abundance of species was determined using the Westhoff and van der Maarel method (1973), and the frequency of species occurring in phytocoenological relevés (I-V) was established according to Braun-Blanquet (1964).

Melliferous potential of the examined vegetation

In each community, the number and percentage contribution of entomophilous and anemophilous plant species were recorded. The intensity of nectar (Inp) and pollen production (Ipp) of each melliferous species was numerically expressed according to Ricciardelli D'Albore and Persano Oddo (1981), Ricciardelli D'Albore (1997) and Umeljić (1999, 2003). Hence, plants were classified into four categories for each of the designated indices (Inp/Ipp 1 – poor nectar or pollen production; Inp/Ipp 2 – good; Inp/Ipp 3 – very good, and Inp/Ipp 4 – excellent). Their melliferous potential was analyzed individually, with respect to their average abundance in the community, as well as their nectar (Cnp) and pollen (Cpp) potential. The coenotic coefficient of melliferousness (CCm) of each community, including summarized coenotic coefficients of nectar and pollen production (CCnp+CCpp), as well as the contribution of melliferous species in the total number of species within the community, was calculated according to the formula suggested by Jarić et al. (2013) as follows:

Table 1. Apifloristic characteristics of investigated plant communities in Vojvodina (CCpp – coenotic coefficient of pollen production, CCnp – coenotic coefficient of nectar production; CCm – coenotic coefficient of melliferousness).

Plant community	Total number of species	Number and % of melliferous species	Number and % of anemophilous species	CCpp	CCnp	CCm
I *Populetum nigrae-albae*	118	78 (66.1%)	39 (33%)	105.9	103.0	137.9
II *Asclepietum syriacae*	141	101 (71.6%)	39 (27.7%)	296.5	323.8	446.6
III *Chenopodio-Ambrosietum artemisiifoliae* ass. nova	183	132 (72.1%)	50(27.3%)	295.9	302.5	598.4
IV *Amorpho-Typhaetum* ass. nova	177	120 (67.8%)	54 (30.5%)	472.4	444.9	623.7
V *Polygonetum convolvulo-avicularis*	98	71 (72.4%)	27 (27.5%)	99.5	99.3	143.6
VI *Consolido-Polygonetum avicularis*	78	63 (80.8%)	15 (19.2%)	101.8	104.5	167.1
VII *Lolio-Plantaginetum majoris*	85	64 (75.3%)	21 (24.7%)	114.95	139.5	190.8

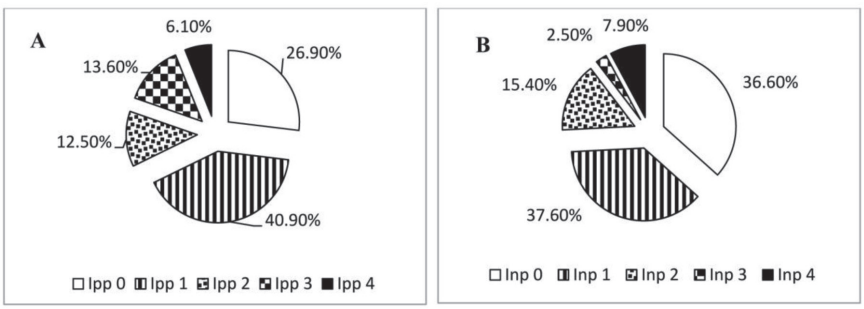

Fig. 1. Percentage share of melliferous plants considering their intensity of pollen and nectar production in all investigated plant communities of southwestern Vojvodina. (**A**) Indices of pollen production (Ipp 0 – 4). (**B**) Indices of nectar production (Inp 0 – 4).

$$CCm = (CCnp+CCpp) \times M/P,$$

where Cnp/Cpp is the coefficient of nectar/pollen production calculated for each species by multiplying the mean value of its abundance in the community by its Inp/Ipp; CCnp/CCpp is the coenotic coefficient of nectar/pollen production calculated for each community by adding up the individual coefficients of nectar (Σ Cnp) and pollen production (Σ Cpp) of all the species in the community; M is the number of melliferous species in the community; P is the total number of species in the community.

RESULTS

Phytocoenological examination of the research area established the presence of seven plant communities belonging to segetal, ruderal and floodplain types of vegetation, as follows: *Polygonetum convolvulo-avicularis* Kojić et al., 1984., *Consolido-Polygonetum avicularis* Kojić et al., 1973., *Lolio-Plantaginetum majoris* Berger 1930., *Asclepietum syriacae* Kojić et al., 2004., *Chenopodio-Ambrosietum artemisiifoliae* ass. nova, *Amorpho-Typhaetum* ass. nova and *Populetum nigrae-albae* Slavnić, 1952. (Table 1).

The flora of the studied area consisted of 279 species classified into 70 families, the species-richest of which were Asteraceae (40), Poaceae (31), Fabaceae (18), Lamiaceae (16) and Polygonaceae (15), indicating the floristic diversity of the region. Of the total number of identified species, 197 were melliferous ones, followed by 79 wind-pollinated plants, whereas three species belong to non-flowering phyla (Equisetophyta and Pteridophyta). The highest percentage of melliferous plants are poor pollen and nectar producers (Ipp 1, 40.9%; Inp 1, 37.6%), whereas the most productive nectariferous and polliniferous plants were under-represented in the research area (Inp 4, 7.9%; Ipp 4, 6.1%) (Fig.1). The communities within ruderal vegetation (especially *Amorpho-Typhaetum*)

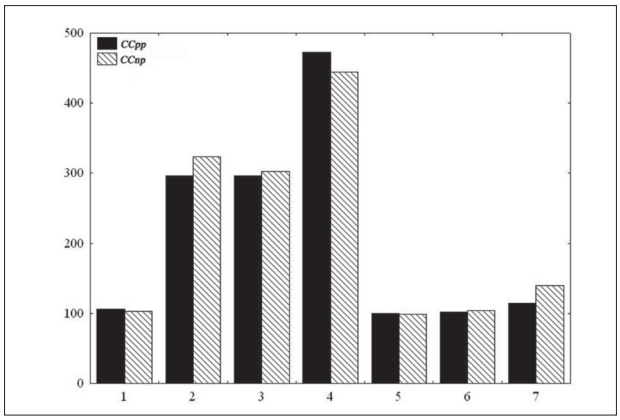

Fig. 2. Comparative contribution of the investigated plant communities to the melliferous potential in the research area of Vojvodina, with respect to their CCnp and CCpp (communities are listed in Table 1).

have much higher values of CCpp and CCnp, in comparison to those in segetal and floodplain vegetation (Fig. 2).

Segetal vegetation in the research area included ass. *Polygonetum convolvulo-avicularis* detected in a corn crop, ass. *Consolido-Polygonetum avicularis*, found in small grain cereals and ass. *Lolio-Plantaginetum majoris* identified in alfalfa crop (*Medicago sativa* L). The highest number of melliferous species were found in the ass. *Polygonetum convolvulo-avicularis*, whereas the highest percentage of these plants (80.8%) was recorded in the ass. *Consolido-Polygonetum avicularis* (Table 1). The largest number of melliferous plants belong to *Asteraceae*, followed by the species-poor families Fabaceae, Polygonaceae, Lamiaceae and Brassicaceae, with the remaining plant families having only one representative.

The largest contribution to the bee pasture of segetal vegetation was provided by species with high

Table 2. The main honey plant contributors to melliferous potential of the research area of southwestern Vojvodina, considering their indices of nectar and pollen production (Inp, Ipp), as well as with respect to their mean abundance and frequency in detected plant communities (listed in Table 1).

Plant species	indices		1		2		3		4		5		6		7	
	Ipp	Inp	Cpp	Cnp	Cpp	Cnp	Cpp	Cnp	Cpp	Cnp	Cpp	Cnp	Cpp	Cnp	Cpp	Cnp
Rubus caesius	4	4	15.1	15.1	14.2	10.6	17.7	17.7	23.6	23.6	1.1	1.1	6.2	6.2	8.6	8.6
Cirsium arvense	2	4	0.2	0.5	5.6	11.2	10.8	21.7	12.8	25.6	10.4	20.7	8.7	17.4	6.3	12.6
Lythrum salicaria	4	2	0.8	0.4	8.4	4.2	11.7	5.8	25.2	12.6	1.8	0.9	5.8	2.9	2.8	1.4
Trifolium pratense	4	4	-	-	21.4	21.4	10.6	10.6	20.8	20.8	2.6	2.6	2.5	2.5	4.6	4.6
Dipsacus laciniatus	3	2	-	-	2.4	1.6	7.9	5.3	14.7	9.8	0.3	0.2	0.8	0.5	1.3	0.9
Medicago sativa	0	4	-	-	0	5.1	-	3.7	-	12.0	-	1.8	-	1.4	-	36.0
Asclepias syriaca	2	4	0.7	1.5	12.0	24.0	5.3	10.6	12.4	6.2	1.3	2.6	2.0	4.0	-	-
Cichorium intybus	1	2	-	-	1.7	3.4	3.4	6.8	5.2	10.4	1.8	3.6	0.6	1.3	1.1	2.2
Taraxacum officinale	4	4	10.9	10.9	10.9	10.9	4.3	4.3	8	8.0	2.2	2.2	-	-	15.4	15.4
Lotus corniculatus	0	4	-	-	5.1	10.2	3.1	6.3	4	8.0	-	-	0.9	1.8	0.9	1.7
Mentha aquatica	1	4	0.5	2	3.5	14.2	0.9	3.7	6.2	12.4	-	-	0.5	2.2	-	-
Stachys annua	1	4	-	-	-	-	1.1	4.3	5.0	5.0	0.5	1.8	1.7	6.9	0.4	1.7
Daucus carota	4	4	-	-	2.9	2.9	14.6	14.6	20	20	8.0	8.0	8.4	8.4	-	-
Trifolium repens	4	4	-	-	12	12.0	4.3	4.3	11.2	11.2	-	-	-	-	6.8	6.8
Salix alba	4	4	0.7	0.7	-	-	1.4	1.4	9.6	9.6	-	-	-	-	-	-
Salix caprea	4	4	0.3	1.3	-	-	0.6	0.6	8.0	8.0	-	-	-	-	-	-
Epilobium hirsuta	3	3	-	-	-	-	3.4	3.4	10.5	10.5	0.3	0.3	-	-	-	-
Carduus acanthoides	3	3	0.8	0.8	0.8	0.8	0.6	0.6	5.7	5.7	-	-	-	-	-	-
Amorpha fruticosa	2	4	5.3	10.5	5.3	10.5	7.1	14.3	10.8	21.6	-	-	-	-	-	-
Stachys palustris	1	4	1	4.1	2.6	10.5	2.1	8.6	3.9	15.6	-	-	-	-	-	-
Crepis setosa	4	1	-	-	-	-	0.8	0.2	4.0	1.0	1.1	0.3	-	-	13.2	3.3

Cnp and Cpp, such as *Cirsium arvense*, *Daucus carota* and *Rubus caesius*. The most abundant weed species, also very frequent in all 3 communities in the cultivated fields, was found to be *Cirsium arvense*, which is an excellent nectariferous and good polliniferous plant (Inp 4; Ipp 2) (Table 2). In addition, the most important species of the same or slightly lower abundance, common to agricultural fields and characterized by the highest nectar and pollen production (Inp 4; Ipp 4) were *Daucus carota* and *Rubus caesius* (particularly very frequent in small grain cereals) (Fig. 3).

However, there was a significantly larger number of species contributing less to the bee pasture, either because of poor pollen and/or nectar production (*Verbena officinalis, Veronica persica, Crepis setosa, Pastinaca sativa, Sinapis arvensis, Polygonum convolvulus, Consolida regalis, Anagallis arvensis* and *Convolvulus arvensis*) or low abundance and frequency (*Trifolium pratense, Lythrum salicaria, Lotus corniculatus, Helianthus tuberosus, Carduus acanthoides, Tussilago farfara, Stachys annua, Asclepias syriaca, Helianthus tuberosus, Medicago lupulina, M. sativa* and *Lythrum hyssopifolia*).

Wind-pollinated plants, which make up about 20-25% of the total number of species, were registered in all investigated communities of segetal vegetation (Table 3). Due to the lack of nectar, they usually have no significance for honeybees and other insect pollinators, but may be beneficial as a source of pollen when food shortage occurs (e.g. *Artemisia vulgaris* and species of *Rumex* and *Plantago*). The majority of anemophilous plants includes grasses (Poaceae), followed by plants from Chenopodiaceae, Polygonaceae, Cyperaceae, Plantaginaceae, Urticaceae, Vitaceae, Cannabaceae and Amaranthaceae. The two anemophilous Asteraceae, present in all observed crop fields, were *Artemisia vulgaris* and *Ambrosia artemisiifolia*.

Ruderal vegetation is commonly found growing on meadows and embankments (ass. *Asclepietum syriacae*), alongside roads and in abandoned areas (ass. *Chenopodio-Ambrosietum artemisiifoliae*), as well as at drainage-canal habitats (ass. *Amorpho-Typhaetum*). The diversity of weed flora was the greatest in this type of vegetation.

Fig. 3. The main plant contributors to melliferous potential of the research area of Vojvodina: *Salix caprea* (a), *Carduus acanthoides* (b), *Dipsacus laciniatus* (c), *Trifolium repens* (d), *Trifolium pratense* (e), *Taraxacum officinale* (f), *Stachys annua* (g), *Rubus caesius* (h), *Mentha aquatica* (i), *Medicago sativa* (j), *Lythrum salicaria* (k), *Lotus corniculatus* (l), *Epilobium hirsutum* (m), *Daucus carota* (n), *Cichorium intybus* (o), *Cirsium arvense* (p), *Asclepias syriaca* (q), *Amorpha fruticosa* (r).

In the ass. *Asclepietum syriacae*, 141 species were registered in total, classified into 43 families, of which 140 were flowering plants (phylum Magnoliophyta) and one belong to the Equisetophyta. Of the total number of species, 71.4% were melliferous ones (Table 1), of which the most abundant (present in 80-100% of analyzed relevés) were *Trifolium pratense*, *T. repens*, *Rubus caesius* and *Taraxacum officinale* (Table 2). Apart from the mentioned plant species, the CCm

Table 3. The anemophilous species in plant communities of the research area of southwestern Vojvodina (communities are listed below the Table).

Plant family	Plant species	I	II	III	IV	V	VI	VII
Aceraceae	*Acer negundo* L.							*
Amaranthaceae	*Amaranthus retroflexus* L.	*		*		*	*	
Asteraceae	*Ambrosia artemisiifolia* L.	*	*	*	*	*	*	
	Artemisia vulgaris L.	*	*	*	*	*	*	
Cannabaceae	*Humulus lupulus* L.	*		*		*	*	*
Chenopodiaceae	*Atriplex patula* L.	*		*		*		
	Chenopodium album L.	*	*	*	*	*	*	*
	C. hybridum L.	*				*		
	C. polyspermum L.	*				*		
Cyperaceae	*Carex divulsa* Good.							*
	C. hirta L.				*			*
	C. remota L.							*
	C. riparia Curt.							*
	C. vulpina L.				*		*	*
	Cyperus fuscus L.		*	*		*	*	
Fagaceae	*Quercus robur* L.				*	*	*	*
Juglandaceae	*Juglans regia* L.					*	*	
Juncaceae	*Juncus articulatus* L.						*	
	J. compressus Jacq.					*	*	
	J. conglomerates L.						*	
Moraceae	*Morus alba* L.				*	*	*	*
	M. nigra L.							*
Oleaceae	*Fraxinus angustifolia* Vahl.				*	*	*	*
	F. lanceolata Borkh. *F. lanceolata*							*
Plantaginaceae	*Plantago lanceolata* L.	*		*	*	*	*	*
	P. major L.	*	*	*	*	*	*	*
Poaceae	*Agropyron repens* (L.) P. Beauv.	*	*	*		*	*	*
	Agrostis alba L.				*	*	*	
	Alopecurus pratensis L.				*	*	*	
	Anthoxanthum odoratum L.				*			
	Arrhenatherum elatius (L.) Mert. et Koch.				*	*	*	
	Brachypodium sylvaticum (Huds.) P. Beauv.						*	*
	Bromus arvensis L.	*		*		*	*	
	B. commutatus Schr.				*			
	B. mollis L.				*	*	*	
	Calamagrostis epigeus (L.) Roth.					*	*	
	Cynodon dactylon (L.) Pers.	*				*	*	
	Dactylis glomerata L.				*	*	*	*
	Digitaria sanguinalis (L.) Scop.	*		*	*			
	Festuca pratensis Huds.				*		*	*
	Holcus lanatus L.				*			*
	Hordeum murinum L.					*	*	*
	Lolium perenne L.	*	*	*	*	*	*	*
	Panicum capillare L.							*
	P. crus-galli L.	*	*	*		*	*	*
	Phleum pratense L.				*	*	*	
	Phragmites communis Trin.						*	*
	Poa annua L.				*	*	*	*

Table 3 continued:

Plant family	Plant species	I	II	III	IV	V	VI	VII
	P. compressa L.				*			
	P. palustris L.				*	*	*	*
	P. pratensis L.	*	*	*	*	*	*	
	P. trivialis L.				*	*		
	Pycreus serotinus (Rott.) Hayek						*	
	Setaria glauca (L.) P. Beauv.	*	*	*		*	*	
	S. viridis (L.) P. Beauv.	*	*	*	*	*	*	
	Sorghum halepense (L.) Pers.	*	*	*	*	*	*	*
	Trisetum flavescens (L.) P. Beauv.				*			
	Triticum sp.		*					
	Zea mays L.	*						
Polygonaceae	*Rumex acetosa* L.				*	*		
	R. conglomeratus Murr.	*			*	*	*	*
	R. crispus L.	*	*	*	*	*	*	
	R. hydrolapathum Huds.						*	
	R. obtusifolius L.	*		*	*	*	*	*
	R. palustris Sm.	*	*		*	*	*	*
	R. patientia L.				*			
	R. sanguinea L.						*	
Potamogetonaceae	*Potamogeton fluitans* Roth.						*	
Salicaceae	*Populus alba* L.					*	*	*
	P. euramericana (Dode) Guin.					*	*	*
	P. nigra L.					*		*
	Salix alba L.					*	*	*
	S. caprea L.					*	*	*
	S. purpurea L.					*		
Sparganiaceae	*Sparganium ramosum* Huds.						*	
Typhaceae	*Typha latifolia* L.						*	
	T. angustifolia L.						*	
Ulmaceae	*Ulmus laevis* Pall.				*	*		*
Urticaceae	*Urtica dioica* L.	*		*	*	*	*	*
Vitaceae	*Vitis sylvestris* Gmel.	*			*	*		*

I *Polygonetum convolvulo-avicularis*; **II** *Consolido-Polygonetum avicularis*; **III** *Lolio-Plantaginetum majoris*; **IV** *Asclepietum syriacae*; **V** *Chenopodio-Ambrosietum artemisiifoliae*; **VI** *Amorpho–Typhaetum*; **VII** *Populetum nigrae-albae;*

value of this community was also influenced by excellent nectariferous plants (*Lotus corniculatus, Cirsium arvense, Asclepias syriaca, Amorpha fruticosa, Medicago arabica, M. lupulina* and *M. sativa*), as well as by low-abundance species (although present on the 60-80% of analyzed relevés), which were characterized by the highest pollen production (*Lythrum salicaria* and *Verbascum blattaria*).

Ass. *Chenopodio-Ambrosietum artemisiifoliae* comprised 183 plant species (182 belonging to phylum Magnoliophyta and one to Equisetophyta), of which 72.1% were melliferous (Table 1). The greatest contribution to the high melliferous potential of the analyzed community was that of *Daucus carota* and *Trifolium pratense* (Table 2). Very good melliferous plants with high indices of nectar and pollen production (Inp/Ipp 4) were *Salix alba, S. caprea, S. purpurea, Taraxacum officinale* and *Trifolium repens*, as well as *Coronilla varia* (Ipp 3; Inp 4), *Helianthus tuberosus* (Ipp 3; Inp 4) and *Brassica oleracea* (Ipp 4; Inp 3), but they were neither abundant nor frequent. The edificatory wind-pollinated *Chenopodium* species

and *Ambrosia artemisiifolia* were present on 86-93% of the analyzed relevés, but since their flowers are nectarless or poor nectar producers, they appeared to be unattractive for bees.

In the recently described *Amorpho-Typhaetum* community, 177 species were registered, of which 2 were non-flowering plants – *Equisetum arvense* (Equisetophyta) and an annual floating aquatic fern, *Salvinia natans* (Pteridophyta). As regards pollination type, 120 were entomophilous, 54 anemophilous, and one was found to be hypohydrophilous (*Ceratophyllum submersum*). Although, most of them are insufficiently attractive to honeybees or other pollinating insects, 67.8% of this community is composed of low-abundance and low-frequency melliferous plants (mostly offering only pollen) (Table 1). However, *Rubus caesius, Daucus carota, Trifolium pratense* and *Salix alba*, followed by *Amorpha fruticosa, Cirsium arvense, Medicago lupulina* and *M. sativa* (Table 2) contributed most to the melliferous potential of the community.

The introduced invasive weed *Amorpha fruticosa*, being the most frequent, largely contributed to the bee pasture in the late spring, due to its numerous inflorescences and attractive, violet-blue flowers rich in nectar and pollen. *A. fruticosa* is a competitively strong and adaptable allochthonous shrubby species, which forms dense bushes in the high humidity habitats of ruderal and flood vegetation. The high frequency of young age classes is the result of favorable habitat conditions, and which points to the expansion of *Amorpha* populations in the research area.

In this community, 10 flowering hydrophytes were recorded, of which those with attractive flowers emerging above water surface are pollinated by insects (*Lemna* sp., *Alisma plantago-aquatica, Butomus umbellatus, Hydrocharis morsus-ranae, Nymphoides flava, Trapa natans*), a few are wind-pollinated (*Potamogeton fluitans, Sparganium ramosum, Typha* sp.) and one is hypohydrophilous (*Ceratophyllum submersum*).

Within ruderal vegetation, anemophilous species constitute, on average, less than 1/3 (27.3-30.5%) of the total number of species of each community. Wind-pollinated plants included either those pollinated exclusively by wind (Poaceae, Juncaceae, Cyperaceae, Chenopodiaceae, Urticaceae, Amaranthaceae), or those pollinated predominantly by wind, but also visited by bees and other pollinating insects (*Plantago major*, *P. lanceolata* and *Artemisia vulgaris*). Sporadically, a few woody, spring-flowering, primarily wind-pollinated polliniferous plants (*Fraxinus angustifolia, Juglans regia, Morus alba, Populus alba, P. euramericana, P. nigra, Quercus robur, Ulmus laevis*) were commonly found. Species pollinated by both wind and insects (*Salix* sp.), as well as shrubby plants primarily very attractive to various insect pollinators including honeybees (*Frangula alnus, Sambucus ebulus, S. nigra, Cornus sanguineus*), were also identified.

Floodplain vegetation was recorded on the alluvial deposit of the coastal part of the Sava River and is represented by the *Populetum nigrae-albae* community. Out of the 118 species registered, one was found to be non-flowering (*Equisetum arvense*). The species-richest plant families were Poaceae (13) and Asteraceae (11). In this community, the vertical distribution of plants is expressed. The growth and development of the herbaceous plants and shrubs are strongly influenced by the specific microclimatic conditions created by the domination of phanerophytes. Weeds grow easily and spread under periodic terrain flooding and anthropogenic influences. With the exception of the commonly found *Rubus caesius*, weed abundance was reduced in this plant community. *Rubus caesius* stands out for its high nectar and pollen production, as well as high abundance and frequency, unlike *Salix alba*, *S. caprea*, *Hedera helix* and *Taraxacum officinale* (that have nectar and pollen-rich flowers), that were only sporadically present. On the other hand, some plants were very frequent (*Galium aparine, Glechoma hederacea, Lamium purpureum, Lysimachia nummularia* and *Stellaria media*) but not generous in their offer of floral forage resources. The most important nectariferous plants (Inp 4) were *Asclepias syriaca, Cirsium arvense, Mentha aquatica* and *Amorpha fruticosa*, among which the most abundant was the last one.

Considering all anemophilous woody species, *Ulmus laevis* has the highest abundance and frequency,

unlike *Populus* species, which are somewhat less abundant due to anthropogenic influence (deforestation). Different trees are the most popular pollen sources at the beginning of the vegetation period when the choice of available floral forage products is very poor (*Acer negundo, Fraxinus angustifolia, F. lanceolata, Populus alba, P. euramericana, P. nigra, Salix alba, S. caprea, Ulmus laevis*, etc.).

DISCUSSION

Comparative analysis of detected phytocoenoses on the territory of northwestern Serbia showed that the greatest number or percentage of melliferous species of the floristically rich communities does not imply the highest melliferous potential. Some other aspects should be taken into consideration, such as abundance and frequency of species, their nectar and pollen potential and environmental factors (microclimate, altitude, relief, etc.) (Jarić et al., 2013). By analyzing the parameters of melliferous potential, it was found that the percentage share of melliferous species in the analyzed communities was not positively correlated with their CCm values. The CCm of two ruderal communities was up to 5 times higher than in the case of floodplain and segetal phytocoenoses. If it is assumed that the coenotic coefficient, theoretically obtained, really reflects the melliferous potential of some plant communities, then the greatest contribution of ruderal communities to the melliferous potential of the research area can be explained with apifloristic diversity, high abundance and high frequency of the majority of melliferous species. According to theoretically obtained values, the highest melliferous potential belongs to the ass. *Amorpho-Typhaetum*, but assessment of its real significance to the bee pasture requires the monitoring of flowering phenology simultaneously with melissopalynological analysis of honey samples collected during the vegetation period in this area. The necessity of this additional research was highlighted by Jarić et al. (2013), who discussed the relation between theoretically obtained values of CCm and the real capacity of apiflora in a similar investigation performed on Mt. Tara. According to literature data (Ricciardelli D'Albore, 1997) that list nectariferous plants, the greatest significance for the bee pasture of the research area should be attributed to the most abundant species: *Rubus caesius, Cirsium arvense* and *Trifolium pratense*. Investigation of weed apiflora in southwestern Vojvodina has shown that some excellent melliferous species, although not very abundant or frequent (*Salix alba, S. caprea, Daucus carota, Amorpha fruticosa*), could be significant for the bee pasture because of the high nectar (and/or pollen) amount provided by their inflorescences. However, according to Grabeljšek (1996), melissopalynological studies showed that length of flowering period and the abundance of some species in vegetation is not of crucial importance for bee pastures compared to species that are more attractive to bees within a specified period of year. On the other hand, the pollen of some other species that are also considered as good melliferous ones and that are very abundant in the observed vegetation, was not found in significant percentage in honey samples. Therefore, Grabeljšek (1996) emphasized the necessity of critical review and the additional research to discover the reasons for the domination and attractiveness of some melliferous species compared to others in actual bee pastures.

The great potential for honey production in the research area derives from the plant diversity of ruderal vegetation growing in different types of habitat: embankments, mowed meadows, roadsides, abandoned arable fields, trampled surfaces and canals, including narrow and wide coastal zones. In addition, a modest contribution was made by underrepresented entomophilous hydrophytes such as *Hydrocharis morsus-ranae, Trapa natans, Alisma plantago-aquatica, Butomus umbellatus, Nymphoides flava*, as well as much more frequent riparian entomophilous hygrophytes (*Lythrum salicaria, Mentha aquatica, Lysimachia nummularia, Euphorbia palustris, Epilobium* sp., *Myosoton aquaticum, Iris pseudacorus, Scutellaria galericulata, Sonchus palustris*).

Segetal communities have much lower CCm compared to ruderal, for several reasons. First, agrophytocoenoses are poorer floristically, and during most of the season, weed apiflora is suppressed due to monoculture domination, mostly cereals, being un-

attractive to pollinating insects. Secondly, the arable land is significantly altered by the high anthropogenic impact of the application of agricultural practices.

Lolio-Plantaginetum majoris stands out in segetal communities with the highest CCm due to the maximum abundance, frequency and nectar potential of alfalfa. Hence, the weed apiflora of this community does not contribute much to the total melliferous potential because of the relatively low abundance and attractiveness of cenobionts in the period of alfalfa mass flowering. In corn and wheat crops, segetal communities are formed parallel to the germination of these cereals. The floristic composition of selected communities is influenced by sowing time and the agroecological conditions that arise from the cultivation of a certain monoculture. Conditions for germination and growth of segetal plants are favorable in the first phases of crop growth because of favorable temperature, humidity and light. During crop growing and development, phytoclimatic conditions are getting worse, which leads to the qualitative and quantitative impoverishment of communities (Jarić, 2009). An increase in CCm mostly occurs due to the late summer and autumn aspects of vegetation that develop after mowing and crop removal. Emerging conditions become favorable for the unrestricted germination and growth of many species being available to bees for longer. The *Consolido-Polygonetum avicularis* and *Polygonetum convolvulo-avicularis* communities contribute less bee pasture compared to alfalfa communities due to the low abundance and frequency of segetal melliferous species.

In segetal vegetation, usually a high abundance and frequency of anemophilous species (including wheat and corn monocultures), as well as unattractive flowers, could be reasons for the the lack of pollinators. For example, characteristic species in ass. *Polygonetum convolvulo-avicularis* (*Setaria viridis, S. glauca, Sorghum halepense, Agropyron repens, Panicum crus-galli, Chenopodium album, Amaranthus retroflexus, Plantago major* and *Artemisia vulgaris*) were highly abundant and frequent, indirectly affecting the CCm. However, low values of CCm cannot always be interpreted within the aspect of anemophilous species, which was the case with the *Lolio-Plantaginetum majoris*. The explanation must be sought elsewhere, for example, by considering the degree of attractiveness of entomophilous species, etc. Despite the negligible nectar and pollen production as well as domination of anemophilous monocultures, i.e. cereals, the melliferous significance of segetal vegetation is increased by the high abundance and frequency of plant edificators. The domination and attractiveness of *Medicago sativa* in the period of mass flowering, affects the highest CCm of *Lolio-Plantaginetum majoris*.

The lowest coenotic coefficient of melliferousness was recorded in floodplain vegetation, due to a higher percentage of anemophilous species. Generally, wind-pollinated plants were the dominant pollen sources in early spring, thereafter replaced by insect-pollinated plants. *Populus* species, as well as *Ulmus laevis, Fraxinus angustifolia, F. lanceolata* and *Acer negundo* in shrub and tree layers, flowering at the beginning of the spring, are interesting for bees, as they obtain large quantities of pollen and honeydew from these plants.

Our results show that the research area was characterized by good melliferous potential that is mostly attributable to the great diversity of apiflora (conditioned by habitat characteristics and anthropogenic impacts), followed by the high abundance and high frequency of species rich in nectar and pollen. All these factors represent a good prerequisite for the development and improvement of beekeeping in this region of Serbia.

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