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Phytoecological Study of Selected Wetlands in Southern Bulgaria

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Abstract. The floristic composition of vascular plants of three moisture zones, along the river Maritsa - "Rice-field Plovdiv", protected zone (PZ) "Rice-field Tsalapitsa" and protected area (PA) "Martvitsata Zlato Pole", was described in terms of phytogeographic elements, biological spectrum, conservation value and anthropogenic impact. The predominant floristic elements in the three areas were European-Asiatic (Eur-As) and European-Mediterranean (Eur-Med). The biological spectrum was limited to 3 life forms: predominant Therophytes (Th), followed by Hemicryptophytes (H) and a small percentage – Phanerophytes (Ph). Fifteen of the identified species have conservation status and they are included in the "IUCN Red List of Threatened Species" with the category "least concern". The anthropogenic impact on the floristic composition of the three areas was expressed in the presence of a large number of weed, ruderal, alien and invasive species.

Key words: protected zone, phytogeographic elements, biological spectrum, conservation value, anthropogenic impact.

Introduction

The specific floristic composition of riparian wetlands is determined by the characteristics of the ecological conditions of the habitat. Wetlands are characterized by high humidity provided both by the river water level and periodic flooding and by the high underground humidity level (VELCHEV, 2002). Some more specific features of vegetation in riparian wetlands were described by STOYANOV (1941). First of all, the richness of climbing plants was mentioned, followed by the presence of wet-soil-loving species.

The wetlands, especially the riparian ones, are extremely important natural sites of high conservation value in compliance with the national and European legislation, included in the Bulgarian Biodiversity Act (BDA, 2002), the Bulgarian Protected Areas Act (PAA, 1998) and Directive 92/43/EEC (EC, 1992) on the conservation of natural habitats and wild fauna and flora. Those are diverse and unique ecosystems requiring priority conservation and restoration activities at national and European level (MARINOV *et al.*, 2007). The middle and lower course of the Maritsa River is a territory of national and European conservation importance. The area of 14693.10 ha is

included in Natura 2000, (code BG0000578). That ecosystem complex is defined as highly vulnerable. That is mainly due to the destruction of riparian forests and the conversion of those areas into arable land.

According to BONDEV (1991), the natural populations of *Salix alba* L., *S. fragilis* L., *Ropulus nigra* L., *P. alba* L. along the Maritsa River were strongly influenced by human activities. In some places the sparse forest cenoses were interplanted with artificial forests or entirely new artificial forests were established, mostly with hybrid poplars. MARINOV *et al.* (2007) mentioned that the banks of the Maritsa River between Plovdiv and Parvomay were heavily modified and influenced to a different degree by abiotic, biotic and anthropogenic factors.

The aim of the present study was to make an environmental assessment on the biological spectrum, phytogeographic elements, conservation value and anthropogenic impact in three selected wetlands along the Maritsa River.

Materials and Methods

The following areas along the Maritsa River were the subject of the present study – "Rice Fields Plovdiv", the protected zone (PZ) "Rice Fields Tsalapitsa" and the protected area (PA) "Martvitsata – Zlato Pole". The first two sites are rice paddies. The melioration and agricultural activities carried out in those areas suggest an increased anthropogenic pressure. PA "Martvitsata – Zlato Pole" is defined as an area of natural origin and less anthropogenic impact.

The analysis of the floristic material was carried out for a two-year period (2017-2018). Each of the three territories was labelled as a 5-km-long transection on which by field surveys and systematic collection of materials, phytoecological study of higher plants in the three selected areas was carried out. The biological spectrum of the life forms of the studied flora was determined by RAUNKIER (1937) and GORISCHINA (1979). The horology and floristic elements were studied following the "Conspectus of the Bulgarian vascular flora" (ASSYOV & PETROVA, 2012).

For identifying the species with conservation value were used: "Red Book of the Republic of Bulgaria" (PEEV, 2011), "Red List of Bulgarian vascular plants" (PETROVA & VLADIMIROV, 2009), IUCN: Red List of Threatened Species (IUCN, 2018), Bulgarian Biological Diversity Act (BDA, 2002), Bern Convention (1979) and The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES, 1975), as reference books and documents.

The weed, ruderal and alien species were determined according to the works of GUSSEV *et al.*, (2004), PETROVA & VLADIMIROV (2001) and STEFANOV & KITANOV (1962). Invasive species were identified according to the "List of worst invasive alien species threatening biodiversity in Europe" (EEA, 2007) and the "Guide to invasive alien species of European Union concern" (TRICHKOVA *et al.*, 2017).

Results and Discussion

The biological spectrum of the flora in the three studied areas, determined according to RAUNKIER classification (1934), showed a presence of 3 life forms only: Hemicryptophytes (H), Therophytes (Th) and Phanerophytes (Ph) - (Fig. 1). The predominant life form in the general floristic composition in the three studied areas was that of Hemicryptophytes, which represent 48.1% of the total number of the established species – 154. A characteristic feature of the analyzed biological spectrum was the relatively high participation of the Therophytes – 66 species or 42.9% of the total number of the species found. The lowest share in the biological spectrum of the studied areas was that of the Phanerophytes – 9.1% or 14 species (Table 1).

The analysis of the biological spectra in the studied areas showed some differences among them. The Therophytes dominated in the "Rice Fields Plovdiv" and PZ "Rice Fields Tsalapitsa". Out of the 72 species of

higher plants found in "Rice Fields Plovdiv", 35 or 48.6% were Therophytes and 31 or 43.1% were Hemicryptophytes. The participation of Therophytes in PZ "Rice Fields Tsalapitsa" was 46.6% or 27 of 58 higher plants found in that area and the Hemicryptophytes were 25 species or 43.1%. In each of the two studied areas, Phanerophytes were 6 in number, representing 8.3% of the total number of species in "Rice Fields Plovdiv" and 10.3% in PZ "Rice Fields Tsalapitsa" (Table 1). The possible reason for the high rate of Therophytes in both areas could be the mass deforestation of the riparian wetlands, especially close to agricultural fields. According to MARINOV *et al.* (2007), that caused the formation of secondary grassland vegetation and the dominance of Therophytes. TASHEV & ANGELOVA (2005) explained the presence of a large number of Therophytes with the formation of shallow and eroded soils as a result of deforestation.

The biological spectrum of PA "Martvitsata – Zlato Pole" was significantly different from that of the other two areas (Fig. 1). The dominating life form was that of Hemicryptophytes – 57 species or 49.6% of the total 115 species of higher plants found in that protected area. The Therophytes were 47 species or 40.9% and the Phanerophytes – 11 or 9.6%, respectively (Table 1). The natural origin and the conservation status of PA "Martvitsata – Zlato Pole" declared as a protected area by Order RD-476 of the Ministry of the Environment and Waters (SG 73/2001), is the reason of the weaker human intervention and the preservation of a larger number of tree species, as well as the presence of a higher percentage of Hemicryptophytes.

The comparison between the biological spectra in the three studied areas and in Bulgaria as a whole (Table 1), determines them as typical for the moderate continental flora but having a high percentage of Therophytes.

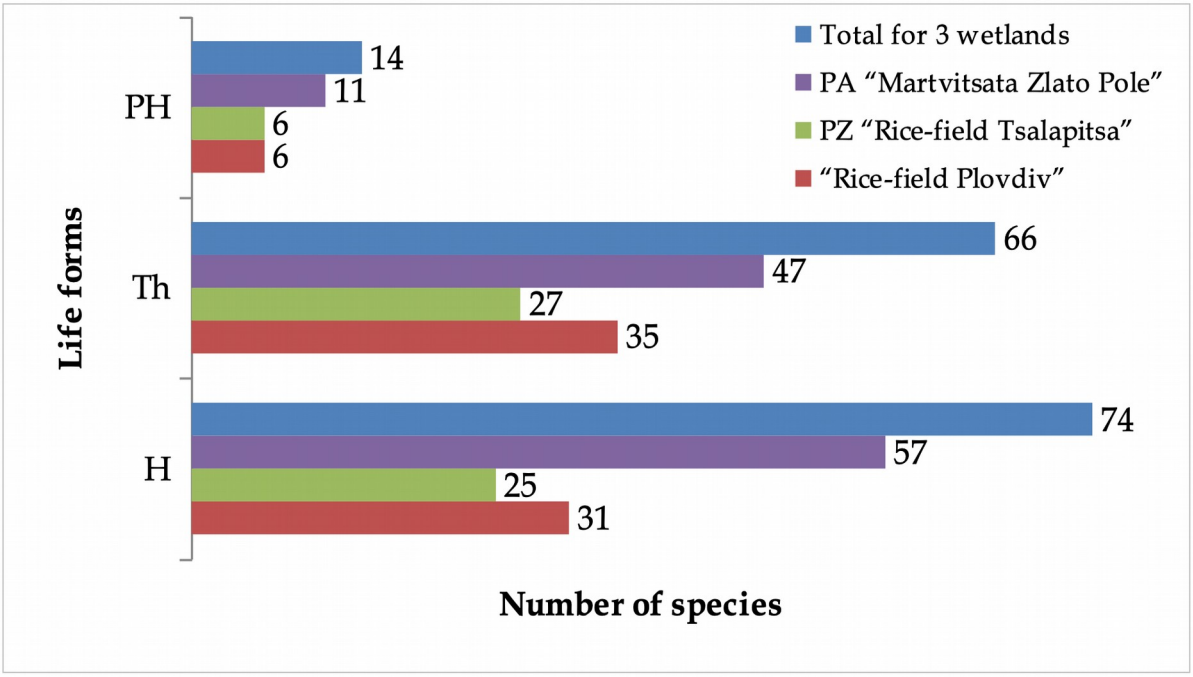

Fig. 1. The biological spectrum of the flora of "Rice-field Plovdiv", PZ "Rice-field Tsalapitsa", PA "Martvitsata Zlato Pole" and in total for the three observed areas.

Table 1. Participation of the life forms in the biological spectrum of "Rice-field Plovdiv", PZ "Rice-field Tsalapitsa", PA "Martvitsata Zlato Pole" and in total for the three observed areas.

Zone	Life form	H	Th	Ph
"Rice-field Plovdiv"	% of the total number in the group of three zones	41.9	53	42.9
	% of the total number of species from the three zones	20.1	22.7	3.9
	% of the total number of species in that zone	43.1	48.6	8.3
PZ "Rice-field Tsalapitsa"	% of the total number in the group of three zones	33.8	40.1	42.9
	% of the total number of species from the three zones	16.2	17.5	3.9
	% of the total number of species in that zone	43.1	46.6	10.3
PA "Martvitsata Zlato Pole"	% of the total number in the group of three zones	77	71.2	78.6
	% of the total number of species from the three zones	37	30.5	7.1
	% of the total number of species in that zone	49.6	40.9	9.6
In total of the three observed areas	% of the total number of species from the three zones	48.1	42.9	9.1
Biological spectrum of Bulgaria % (TASHEV & ANGELOVA, 2005)		**55**	**27**	**12**

The distribution of floristic elements according to the classification of ASSYOV & PETROVA (2012) showed similarity both in terms of total floristic composition and separately for each of the three areas (Fig. 2). The most common was the European element, with the European-Asian species (Eur-As) being 38 of the total number of species identified in the three studied areas or 24.7% (Table 2). The European-Mediterranean (Eur-Med) species ranked second – 24 species or 15.6%. The European-Siberian (Eur-Sib) and European (Eur) species were 10 or 6.5% and 7 or 4.5%, respectively. Boreal and cosmopolitan (Kos) species were respectively 18 or 11.7% and 17 or 11% of the 154 species of higher plants found.

The comparative analysis of the floristic elements in "Rice Fields Plovdiv" showed a smaller share of the European species (Eur) – 2.8% of the species composition of the (Table 2). For comparison, that percentage was 5.2% for the other two studied areas. A relatively low percentage of subBoreal species (3.4%) was found for the PZ "Rice Fields Tsalapitsa". The adventive elements (Adv and NAm(Adv.) were 4.8% of the total number of species. The highest share of those elements was found for "Rice Fields Plovdiv" – 2.8% (Adv) and 2.8% (Nam(Adv.). In "Rice Fields Tsalapitsa" the share was 1.7% for each of those two groups and for PA "Martvitsata Zlato Pole" – 0.9% (Adv.) and 2.6% (NAm(Adv.), respectively (Table 2). The presence of anthropogenic activity in the three areas, deforestation and the specific climatic characteristics favoured the development of more European, boreal and cosmopolitan species in the flora (DIMITROVA *et al.*, 2009).

A total of 15 species were found in the three studied areas with a conservation value of least concern (LC) according to the Red List of IUCN (IUCN, 2018), (Table 3).

As it was expected, the largest number of species of conservation value was reported for PA "Martvitsata – Zlato Pole" – 11, which represents 7.1% of the total number of species found in the three areas or 9.6% of the floristic composition of that area (Fig. 3). For "Rice Fields Plovdiv" and PZ "Rice Fields Tsalapitsa" the percentage

of species of conservation value to the total species composition was similar – 5.6% and 5.2%, respectively (Fig. 3). Six Tertiary relicts were found in the flora of the studied wetlands: *Salix alba* L., *Salix fragilis* L., *Salix purpurea* L., *Rumex crispus* L., *Phragmites australis* (Cav.) Steud., *Populus nigra* L.

The anthropogenic impact on the species composition of higher plants was quite obvious in all the three studied areas where a large number of weed, ruderal, alien and invasive species had entered (Table 4). Most of the species represented in the three areas referred to the group of weed and ruderal species (Fig. 4).

The calculated percentage of each of the four groups to the total number of weeds (26), of ruderals (26), alien (6) and invasive species (6) in each area, showed the lowest values in PZ "Rice Fields Tsalapitsa" – 61.5%, 65.4%, 16.7% and 16.7%, respectively. The lowest values were found again for that area when calculating the share of each of those four groups to the total number of species in the three areas (Table 5). However, the percentage of weeds and ruderals to the total number of species in the area was the highest (27.6% and 29.3%, respectively). The reason for those high values was the fact that the lowest number of species was found in that area.

The anthropogenic impact on PA "Martvitsata – Zlato Pole" had the lowest values concerning the share of the four groups of anthropogenically related taxa to the total number of species in that area – 14.8% of weeds; 16.5% of ruderals and 3.5% of alien and invasive species. That is basically due to the richest floristic diversity in the protected area.

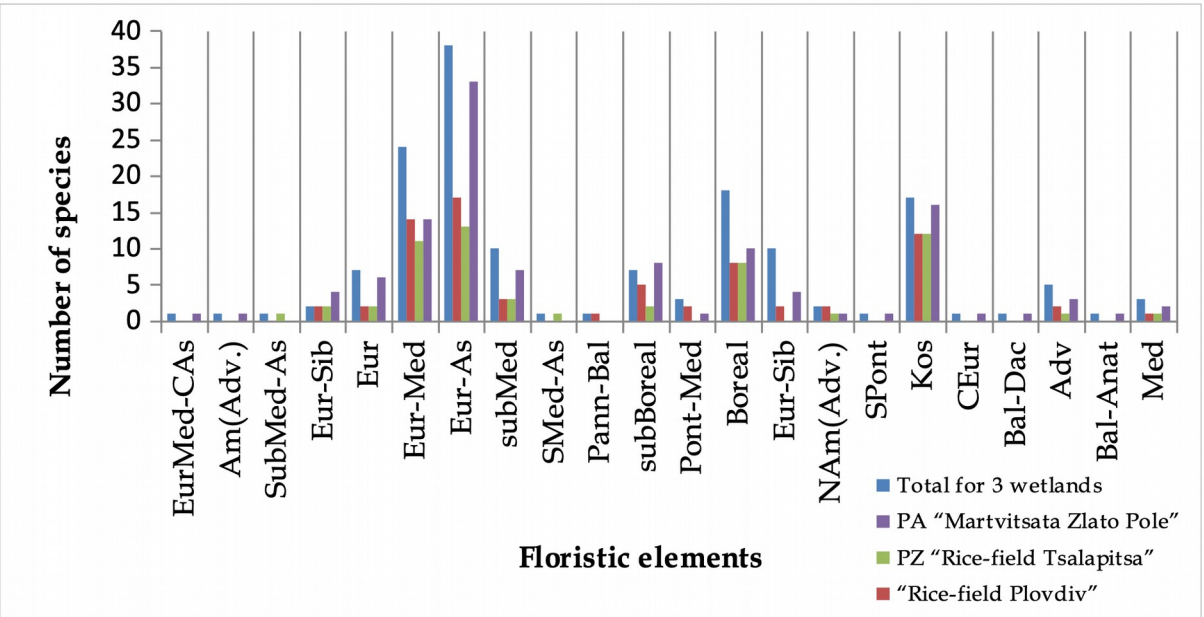

Fig. 2. The distribution of floristic elements "Rice-field Plovdiv", PZ "Rice-field Tsalapitsa", PA "Martvitsata Zlato Pole" and in total for the three observed areas, according to Assyov & Petrova (2012). *Floristic element:* EurMed-CAs – European-Mediterranean-Central-Asiatic; Am(Adv.) - American(Adventive); subMed-As - Submediterranean-Asian; Eur-Sib - Euro-Siberian; Eur – European; Eur-Med - Euro-Mediterranean; Eur-As - Euro-Asian; subMed – Submediterranean; SMed-As – South-Mediterranean-Asian; Pann-Bal – Pannonian-Balkan; subBoreal – Subboreal; Pont-Med – Pontic-Mediterranean; Boreal; Eur-Sib – European-Siberian; NAm(Adv.) – Nort American(Adventive); SPont – South Pontic; Kos – Cosmopolitan; CEur – Central European; Bal-Dac – Balkan-Dacian; Adv – Adventive; Bal-Anat – Balkan-Anatolian; Med– Mediterranean.

Table 2. Participation of floristic elements in "Rice-field Plovdiv", PZ "Rice-field Tsalapitsa", PA "Martvitsata Zlato Pole" and in total for the three observed areas.

Area	**"Rice-field Plovdiv"**		**PZ "Rice-field Tsalapitsa"**		**PA "Martvitsata Zlato Pole"**		**In general of the three observed areas**
Floristic elements	% of the total number established for the three zones	% of the total number of species in that area	% of the total number established for the three zones	% of the total number of species in that area	% of the total number established for the three zones	% of the total number of species in that area	% of the total number established for the three zones
EurMed-Cas	-	-	-	-	0.6	0.9	0.6
Am(Adv.)	-	-	-	-	0.6	0.9	0.6
SubMed-As	-	-	0.6	1.7	-	-	0.6
Eur-Sib	1.3	2.8	1.3	3.4	2.6	3.5	1.3
Eur	1.3	2.8	1.9	5.2	3.9	5.2	4.5
Eur-Med	9.1	19.4	7.1	18.9	9.1	12.2	15.6
Eur-As	11	23.6	8.4	22.4	21.4	28.7	24.7
subMed	1.9	4.2	1.9	5.2	4.5	6.1	6.5
SMed-As	-	-	0.6	1.7	-	-	0.6
Pann-Bal	0.6	1.4	-	-	-	-	0.6
subBoreal	3.2	6.9	1.3	3.4	5.2	7	4.5
Pont-Med	1.3	2.8	-	-	0.6	0.9	1.9
Boreal	5.2	11.1	5.2	13.8	6.5	8.7	11.7
Eur-Sib	1.3	2.8	-	-	2.6	3.5	6.5
NAm(Adv.)	1.3	2.8	0.6	1.7	0.6	0.9	1.3
SPont	-	-	-	-	0.6	0.9	0.6
Kos	7.8	16.7	7.8	20.7	10.4	14	11
CEur	-	-	-	-	0.6	0.9	0.6
Bal-Dac	-	-	-	-	0.6	0.9	0.6
Adv	1.3	2.8	0.6	1.7	1.9	2.6	3.2
Bal-Anat	-	-	-	-	0.6	0.9	0.6
Med	0.6	1.4	0.6	1.7	1.3	1.7	1.9

Table 3. Plant species with conservation value LC – least concern (according to IUCN, 2018) in "Rice-field Plovdiv", PZ "Rice-field Tsalapitsa", PA "Martvitsata Zlato Pole".

Taxon		"Rice-field Plovdiv"	PZ "Rice-field Tsalapitsa"	PA "Martvitsata Zlato Pole"
Achillea crithmifolia Friv. ex Hampe		LC		
Bidens tripartita L.				LC
Butomus umbellatus L.				LC
Cyperus longus L.			LC	
Myriophyllum spicatum L.				LC
Lycopus europaeus L.				LC
Mentha aquatica L.				LC
Lemna minor L.				LC
Lythrum salicaria L.		LC		LC
Epilobium hirsutum L.		LC	LC	
Potamogeton crispus L.		LC		LC
Plantago major L.				LC
Salix alba L.				LC
Sparganium erectum L.				LC
Typha latifolia L.			LC	
Total	**15**	**4**	**3**	**11**

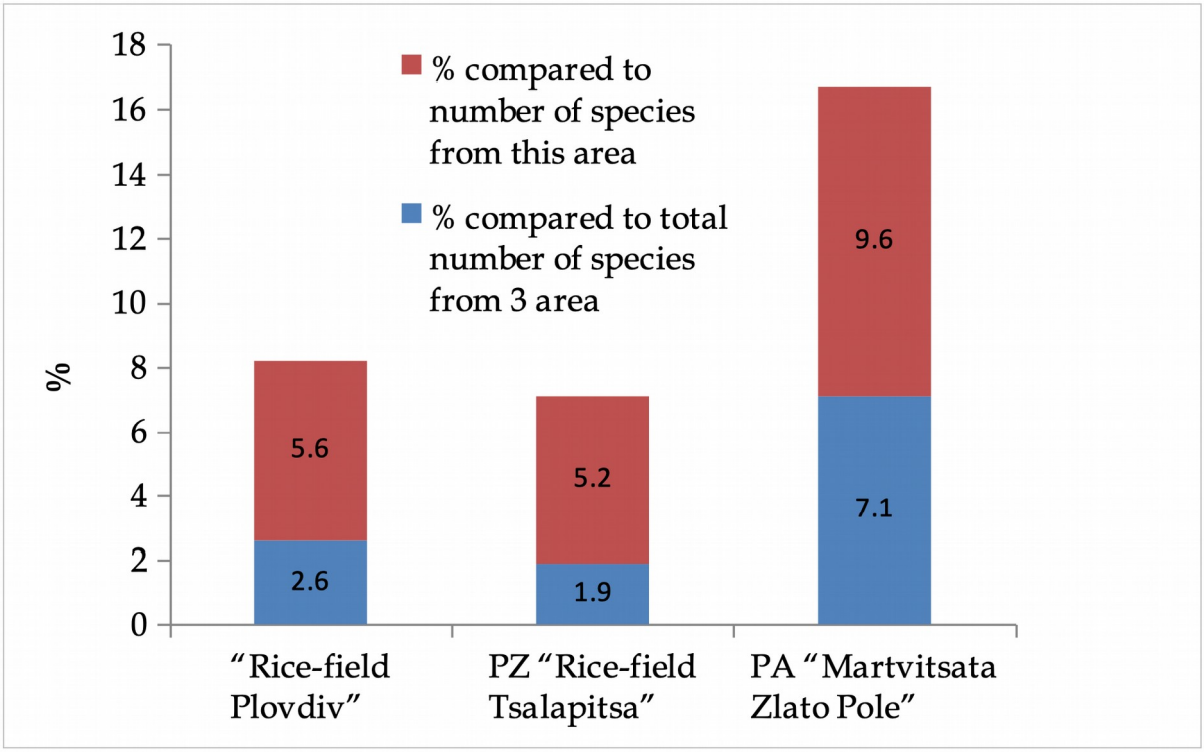

Fig. 3. Share of conservation species in "Rice-field Plovdiv", PZ "Rice-field Tsalapitsa", PA "Martvitsata Zlato Pole" and in total for the three observed areas.

Table 4. Plant species associated with anthropogenic impact in "Rice-field Plovdiv", PZ "Rice-field Tsalapitsa", PA "Martvitsata Zlato Pole".

Taxon	Weaves	Ruderal	Alien	Invasive
Ailanthus altissima (Mill.) Swingle			+	+
Agrimonia eupatoria L.		+		
Agropyron repens (L.) P. Beauv.	+			
Amorpha fruticosa L.			+	+
Artemisia vulgaris L.		+		
Arctium lappa L.	+			
Aristolochia clematitis L.	+			
Avena fatua L.	+			
Ballota nigra L.		+		
Bromus sterilis L.		+		
Canabis sativa L.			+	
Cardaria draba (L.) Desv.	+	+		
Carduus acanthoides L.		+		
Carthamus lanatus L.		+		
Chenopodium album L.	+			
Cichorium intybus L.	+	+		
Cirsium arvense (L.) Scop.	+	+		
Cirsium vulgare (Savi) Ten	+	+		
Conium maculatum L.	+			
Convolvulus arvensis L.	+			
Conyza canadensis (L.) Cronq.	+	+	+	+
Cuscuta europaea Bove & Engelm.	+			
Cynodon dactilon (L.) Pers.	+	+		
Daucus carota L.		+		
Filago vulgaris Lam.	+			
Fraxinus americana L.			+	+
Galium aparine L.	+	+		
Koelreuteria paniculata Laxm.			+	+
Lactuca serriola L.	+			
Lamium purpureum L.	+			
Lythrum salicaria L.		+		
Malva sylvestris L.	+	+		
Onopordum acanthium L.		+		
Portulaca oleraceae L.	+			
Rubus caesius L.		+		
Rumex crispus L.		+		
Sambucus nigra L.	+	+		
Setaria glauca (L.) P.Beauv.	+			
Setaria viridis (L.) P.Beauv.	+			
Sorghum halepense (L.) Pers.	+			
Taraxacum officinale L.		+		
Tragopogon dubius Scop.		+		
Thlaspi arvense L.	+	+		
Torilis arvensis (Huds.) Link		+		
Urtica dioica L.	+	+		
Verbascum speciosum Schrader		+		
Xanthium strumarium L.				+
Total	**26**	**26**	**6**	**6**

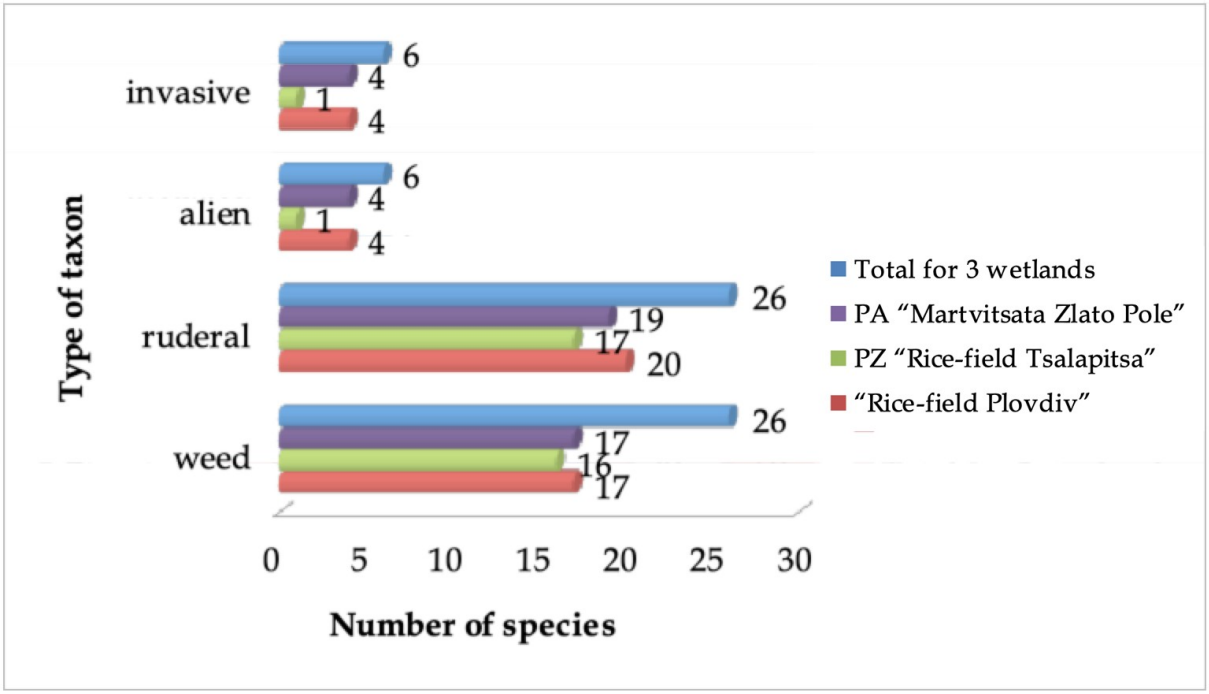

Fig. 4. Participation of anthropogenically related taxon in "Rice-field Plovdiv", PZ "Rice-field Tsalapitsa", PA "Martvitsata Zlato Pole" and in in total for the three observed areas.

Conclusions

The ecological study of flora in the three riparian wetlands along the Maritza River valley showed different levels of anthropogenic impacts.

The plants of European origin predominated in the phytogeographic elements. A high percentage of boreal and cosmopolitan floristic elements were also reported. Adventive species also occupy a relatively high share in the studied areas, which is an indicator of the anthropogenic influence.

The analysis of the biological spectra of the flora showed that the areas PZ "Rice Fields Tsalapitsa" and "Rice Fields Plovdiv" were subject to a stronger anthropogenic impact, as the predominant life form in those areas being the Therophytes (Th).

The largest number of species having a high conservation value according to IUCN and the lowest share of weeds, ruderals, alien and invasive species were reported in the PA "Martvitsata – Zlato Pole", which indicates the lower anthropogenic pressure on that wetland area.

Acknowledgements

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References

ASSYOV B., A. PETROVA. (Eds.). 2012. *Conspectus of the Bulgarian Vascular Flora. Distribution Maps and Florestic Elements.* Ed. 4, Sofia. Bulgarian Biodiversity Foundation.

Bern Convention. 1979. *Convention on the Conservation of European Wildlife and Natural Habitats. Appendix I.* Bern. Switzerland.

BDA. 2002. Biological Diversity Act. - *State Gazette,* 77(9.08.2002): 9-42. Available at: [lex.bg]. (In Bulgarian).

BONDEV I. 1991. *The Vegetation of Bulgaria. Map in scale 1:600000 with explanatory text.* Sofia, Publ. House of Sofia University "St. Kliment Ochridsky".

CITES. 1975. Convention on International Trade in Endangered Species of Wild Fauna and Flora, July 1 1975. Available at: [cites.org].

DIMITROVA V., M. LYBENOVA, M. ASENOVA. 2009. Floristic investigation of the Chestnut (*Castanea sativa* Mill.) communities in the West Balkan region. - *Forestry Ideas*, 1(37): 28-39.

EC. 2006. Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora. Amended by Council Directive 2006/105/EC of 20 November 2006), accessible on-line at: [eur-lex.europa.eu].

GORISCHINA T. 1979. [*Plants ecology*]. Moscow. (In Russian).

GUSEV C., S. BANCHEVA, D. DIMITROV, C. DENVHEV, D. PAVLOVA, Y. KOEVA, D. PATRONOV. 2004. [*Floristics characteristics of the biosphere reserve Uzunbudzhak of Strandja*]. Sofia. Nature park Strandja, Malko Tarnovo, 64 p. (In Bulgarian).

IUCN. 2018. IUCN Red List of Threatened Species. Version 2018-2. Available at: [iucnredlist.org].

EEA. 2007. List of the most dangerous invasive alien species threatening Europe's biodiversity. - In: *Halting the loss of biodiversity by 2010: proposal for a first set of indicators to monitor progress in Europe.* European Environmental Agency Technical Report, vol. 11, pp. 104-109. Available at: [eea.europa.eu].

MARINOV M., D. TODOROV, V. VASILEV, S. CHESMEDJIEV. 2007. [*Riverside Introzonal vegatation and hydromorphology in Maritsa coast the parties between Plovdiv and Parvomay.*] Report. Plovdiv. Available at: [rivers.biodiversity.bg]. (In Bulgarian).

PEEV D., A. PETROVA, M. ANCHEV, TEMNISKOVA, C.M. DENCHEV, A. GANEVA, C. GUSSEV, V. VLADIMIROV. 2015. *Red data book of the Republic of Bulgaria. Vol. 1. Plants and fungi*. Institute of Biodiversity and Ecosystem Research & Ministry of Environment and Water, Sofia, Available at: [e-ecodb.bas.bg].

PETROVA A., V. VLADIMIROV. 2001. Anthropophyte flora of Bulgaria. - In: *Proceedings of scientific papers, VI National scientific conference of Botany, Sofia,* pp. 18-21.

PETROVA A., V. VLADIMIROV (Eds). 2009. Red List of Bulgarian vascular plants. *Phytologia Balcanica*, 15(1): 63-94.

PAA. 1998. Protected Areas Act. - *State Gazette,* 133(11.11.1998): 1-246. Available at: [lex.bg]. (In Bulgarian).

RAUNKIER C. 1934. *The Life Forms of Plant and Statistical Plant Geography*. Oxford University Press, Clarendon.

STEFANOV B., B. KITANOV. 1962. [*Cultigen plants and cultigen vegetation in Bulgaria*]. BAS, Sofia. (In Bulgarian).

STOYANOV N. 1941. Attempt at characterization of the main phytocoenoses in Bulgaria. - *Annuaire de l'Université de Sofia" St. Kliment Ohridski.": Faculté de mathématiques et phisitique* 37(2): 93-194.

TASHEV A., K. ANGELOVA. 2005. [Systematic and phytogeographic analysis of the flora of Chepan Mount]. - *Forestry Ideas,* 1(30): 17-34. (In Bulgarian).

TRICHKOVA T., V. VLADIMIROV, R. TOMOV, M. TODOROV (Eds.). 2017. *Guide to invasive alien species of European Union concern.* IBER-BAS, ESENIAS, Sofia.

VELCHEV V. 2002. [*Types of vegetation. Geography of Bulgaria, Physical and socio-economic geography*[, Sofia, ForKom Publishers. (In Bulgarian).

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