Study on the psammophytic grasslands along River Maritsa in the Thracian Lowland, Bulgaria

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Received: February 23, 2023 ▷ Accepted: April 08, 2023

Abstract. This paper presents the results of the first phytocoenological analysis of psammophytic semi-ruderal vegetation on the alluvial terraces of River Maritsa in the Thracian Lowland, Bulgaria. During the field study, new syntaxa for Bulgaria have been found. The new alliance for Bulgaria, *Salsolion ruthenicae* (class *Digitario sanguinalis-Eragrostietea minoris*), is represented by the association *Erysimo diffusi-Cynodontetum dactylontis*, which is widespread on the sand deposits in the river's floodplain. A comparatively high level of ruderalisation influences the communities on the alluvial sands. The species composition of the communities reveals a mixture of perennial species (*Cynodon dactylon, Bothriochloa ischaemum, Eryngium campestre*), annual psammophytes (*Plantago arenaria, Silene conica, Lomelosia argentea*) and nitrophilous species, including neophytes (*Portulaca oleracea, Tragus racemosus, Erigeron canadensis*). The communities in this association differ from those in Central Europe and this has prompted the description of a new subassociation (*Poaetosum bulbosae*).

Key words: alluvial sands, semiruderal vegetation, alliance *Salsolion ruthenicae*

Citation: Tzonev, R., Gussev, Ch., Georgiev, V., Tsoneva, S. 2023. Study on the psammophytic grasslands along River Maritsa in the Thracian Lowland, Bulgaria. -- Phytologia Balcanica, 29 (1): 97-106. -- ISSN 1310-7771 (print), 1314-0027 (online).

Introduction

Psammophytic vegetation in Bulgaria is distributed mainly along the Black Sea Coast (Bondev 1991), but also on the alluvial dunes near the Danube River (Tzonev 2015). The plant communities on the dunes of the Black Sea Coast have been relatively well studied depending on the levels of sand stabilization (Tzonev & al. 2005; Marceno & al. 2018; Valcheva & al. 2021b), while specific syntaxonomic studies of the vegetation

DOI 10.7546/PhB.29.1.2023.10

on the alluvial dunes along Danube River (Tzonev 2009; Valcheva & al. 2021a) are more limited. Generally, almost nothing is known about inland psammophytic communities far from the Danube and the Black Sea Coast.

In the summer of 2022, the authors of this publication carried out a survey of the mapped habitats under the project „Mapping and determination of the conservation status of natural habitats and species. Phase 1", carried out in the period 2011–2013 (MoEW). It was found that the land polygons, mapped out as belonging to the natural habitat 6220* Pseudo-steppes with grasses and annuals of the *Thero-Brachypodietea,* were actually occupied by psammophytic semi-ruderal plant communities. Those communities were widespread across the alluvial lowland terraces of the river. An analysis of the relevés has shown that these communities belong to the alliance *Salsolion ruthenicae*, so far not reported for Bulgaria (Tzonev & al. 2009). The present study is the first one on the inland semiruderal psammophytic vegetation, or more specifically, of this vegetation in the floodplain terraces of the second largest river in Bulgaria.

Material and methods

The vegetation was studied in the summer of 2022, within the framework of the project for specific objectives for NATURA 2000 site BG0000578 Reka Maritsa. As it was already mentioned, the investigated plots were mapped out earlier as priority habitat 6220* Pseudo-steppes with grasses and annuals of the *Thero-Brachypodietea*.

The new research followed the classical methodology of the sigmatic school (Braun-Blanquet 1964). Braun-Blanquet's expanded scale (1932) for abundance/dominance was applied, modified according to Van der Maarel (1979) for statistical processing. Cluster analysis of the relevés was performed with SYNTAXA software (Podani 2001). The average linkage method (UPGMA) was used and floristic similarity among the relevés was evaluated according to Horn's index (Krebs 1999). Taxonomic nomenclature followed Delipavlov & Cheshmedzhiev (eds) (2003) and Euro+Med (2006+), especially for the species *Anisantha tectorum* (≡ *Bromus tectorum*), *Lomelosia argentea* (≡ *Scabiosa argentea*), *Dysphania botrys* (≡ *Chenopodium botrys*), *Psammophiliella muralis* (≡ *Gypsophila muralis*), and *Plantago arenaria* (=*Plantago indica*). The new syntaxa have been published according to the rules of the International Code of Phytosociological Nomenclature (Theurillat & al. 2021) and in line with the cited references. The work of Mucina & al. (2016) was leading for determination of the synoptic schema. For the investigated communities in particular, the most topical information from the neighboring Balkan countries and from Central Europe came from the works of Jarolímek & al. (1997); Jarolímek & Šibik (eds). (2008); Chytry (ed.) (2009); Borhidi (2003); Borhidi & al. (2012), Sanda & al. (2008); Coldea (ed.) (2012); Koijc & al. (1998), etc.

Climate along River Maritsa (Velev 1990; Yordanova & al. 2002) is transitional continental (Plovdiv-Pazardzhik region) in the central section, and varies to continental Mediterranean in the southeastern (Haskovo-Svilengrad) parts. Under transitional continental climatic influence, the winter is mild and the annual air amplitude is lower. Precipitation has two peaks (in July and November) and two lows (in August and February), while the snow cover is unsteady. In the region of Plovdiv and Pazadzhik, River Maritsa falls in the rain shadow of the Rhodopes, with hot summers and interminable drought periods. The lower stretches of the River are under continental Mediterranean climatic influence, characteristically, with even greater softening of the climate, precipitation peaks in autumn-winter and no snow cover in winter.

Geology and geomorphology of the valley of River Maritsa are strongly dependent on the lowland development. There are seven supra-flood terraces (Angelova & al. 1993). The studied communities have been spread on the flooded terraces formed by the negative morpho-structural movement during contemporary Quaternary and especially during the Holocene. They are divided into higher, lower and bedside terrace. The higher flooded terrace of erosion-accumulative genesis could be traced along both riverbanks, as

high as 6-7 m at the town of Belovo. The alluvium is 2 m thick, mainly in the bedside terrace. Near Belovo town, the terrace is only 250 m wide, while between the towns of Septemvri and Plovdiv, it stretches about 2-3 km in width. The alluvium comprises sands, interlayers of small pebbles and rare kernels of slightly clayey sands. The lower alluvial terrace has 1.5-2 m thick alluvial deposits, composed mainly of small and medium-sized gravels with variable composition, but mostly metamorphic. The terrace width varies from 200 m to 3 km in the Plovdiv depression. The deposits are formed by spill structures, of medium-grained sands, which become finer eastwards of Orizari village, as far as Plovdiv. Near Trivoditsi village (Pazardzhik district), the thickness of the alluvium reaches 4 m, and at the town of Lyubimets it increases to 10-12 m. The bedside alluvial terrace is developed only in the bends of the large meanders, on islands and drained old riverbeds, where it forms characteristic sandspits. It is composed of gravel and clay-sandy sediments (Angelova & al. 1993). The floodplain terraces are covered with alluvial soils (Fluvisols) (Ninov 2002). However, they are poor and strongly eroded mainly because of the changing river stream, especially during overfloods. Investigations in the area of ancient Pistiros, near Vetren village (Pazardzhik district) (Baltakova & al. 2013), have shown numerous traces of abandones old channels in the lowland, remaining from the river migration on the territory. Micro elevations occupied by psammophytic vegetation are actually small sandy-gravel bars (islets) shaped by temporary river channels (streams) and drying oxbows. They resemble the dunes in the Danubian Plain, but actually are mostly of alluvial-accumulative origin. However, certain influence of Aeolian processes is not excluded.

Results and discussion

The following syntaxonomic schema is presented as a result from the undertaken analysis (Fig. 1):

Class *Digitario sanguinalis-Eragrostietea minoris* Mucina, Lososová & Šilc in Mucina & al. 2016

Order *Eragrostietalia* J. Tx. ex Poli 1966

Alliance *Salsolion ruthenicae* Philippi ex Oberd. 1983

Association *Erysimo diffusi-Cynodontetum dactylontis* (Jarolímek & al. 1997) Borhidi 2003 subass. *poaetosum bulbosae* subass. nova.

The studied communities have been widespread only on the alluvial sands and gravels along River Maritsa, always not very far from the main river course. Geographically, they are located in the Thracian Lowland (Fig. 2), South Bulgaria.

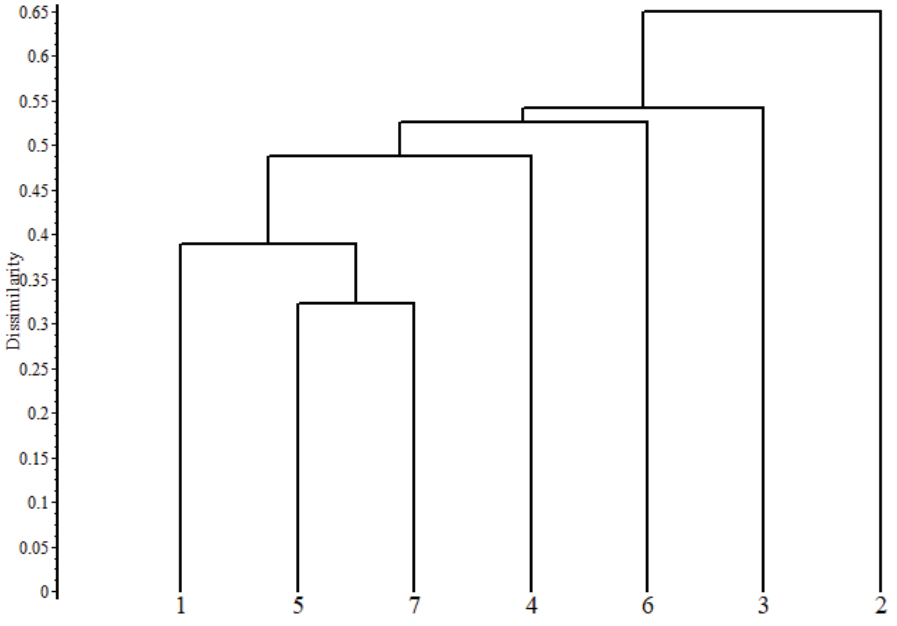

Fig. 1. Dendrogram of the hierarchical clustering of studied communities.

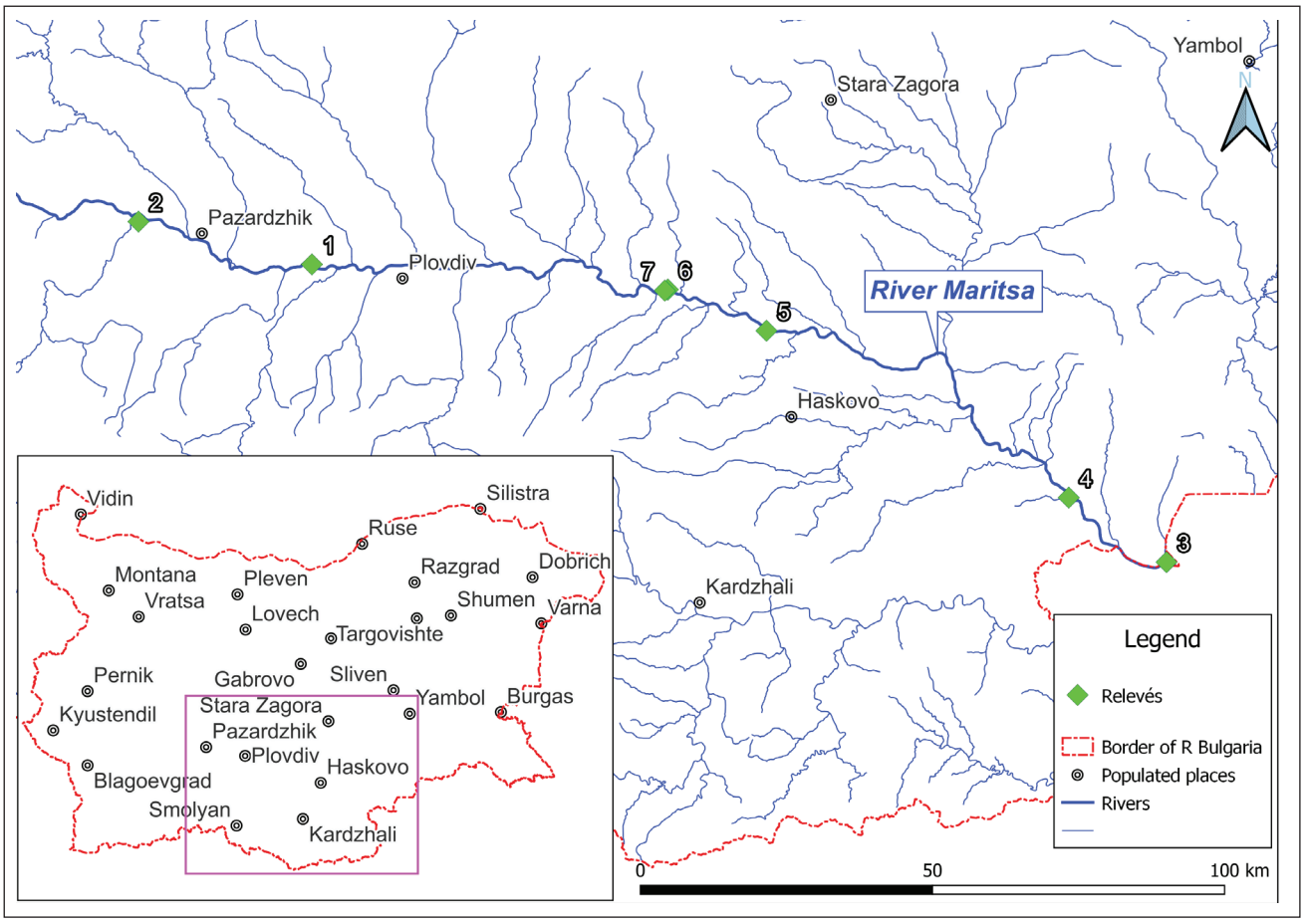

Fig. 2. Map of the studied communities of the association *Erysimo diffusi-Cynodontetum dactylontis.*

Vegetation along River Maritsa has been at a different level of ruderalization everywhere near the river course. The studied communities (Table 1) have been semi-open xeromesophilous grasslands (Fig. 1), with coverage varying between 60% and 80%. It usually depended on the degree of compactness of the sand substrates and the existing soil layer. In some parts of the alluvial lowlands, the substrates could be a mixture of sands and small-grained gravels. *Cynodon dactylon* was the dominant perennial species, but the coverage of the annual *Plantago arenaria* has been even greater. The composition of the communities has been a mixture of perennial and annual species. Perennial species have been also typical for the xerophytic grasslands: *Eryngium campestre, Bothriochloa ischaemum, Euphorbia cyparissias, Verbascum banaticum,* and *Poa bulbosa*. The group of annuals was more numerous and included *Anisantha tectorum, Anthemis ruthenica, Erysimum diffusum, Tribulus terrestris, Portulaca oleracea, Erigeron canadensis, Tragopogon dubius*, etc. Some therophytes have also been neophytes. The level of ruderalization could also vary. Typical rudelal and nitrophilous species have been *Centaurea solstitialis, Onopordum tauricum, Marrubium peregrinum, Heliotropium europaeum*, etc. However, it should be pointed out that there were typical psammophytes (*Silene conica, Lomelosia argentea, Plantago arenaria*), as well as subhalophytes (*Cynodon dactylon, Spergularia media*), because of the salinization processes in the lower part of alluvial lowlands.

Table 1. Diagnostic table of the association *Erysimo diffusi-Cynodontetum dactylontis* (Jarolímek & al. 1997) Borhidi 2003 subassociation *poaetosum bulbosae* subass. nova holoypus relevé number 6 hoc loco. The holotypus relevé is marked with asterisk (*).

Relevé number	**1**	**2**	**3**	**4**	**5**	**6***	**7**	
Latitude	**42.15227**	**42.20992**	**41.71708**	**41.81535**	**42.06617**	**42.12675**	**42.12512**	
Longitude	**24.55696**	**24.19522**	**26.3322**	**26.12962**	**25.50083**	**25.29524**	**25.28894**	
Total cover (%)	**80**	**60**	**70**	**60**	**60**	**70**	**70**	
Sample area (sq. m)	**12**	**25**	**20**	**25**	**25**	**25**	**25**	
Locality	**Stamboliyski town**	**Kovachevo village**	**Kapitan Andreevo village**	**Lyubimets town**	**Krum village**	**Parvomay town**	**Parvomay town**	**Constancy (%)**
Dates	**27.7.22**	**28.7.22**	**24.8.22**	**24.8.22**	**26.8.22**	**26.8.22**	**26.8.22**	
Diagnostic species for the association *Erysimo diffusi-Cynodontetum dactylontis*								
Cynodon dactylon (L.) Pers.	3	2	2	2	2	2	2	100
Plantago arenaria Waldst. & Kit.	4	3	3	3	3	3	2	100
Anthemis ruthenica M. Bieb.				1	+	+		57
Erysimum diffusum Ehrh.	+				1		1	43
Euphorbia cyparissias L.					+		+	29
Differential species for the subassociation *poaetosum bulbosae* subass. nova holotypus relevé number 6 hoc loco								
Poa bulbosa L.			3		4	4	5	71
Eryngium campestre L.	+			2		+	2	71
Anchusa procera Besser			1	2	+	+		57
Achillea pseudopectinata Janka		2					1	29
Lomelosia argentea (L.) Greuter & Burdet						1	2	29
Verbascum banaticum Schrad.						1		14
Diagnostic species for the alliance *Salsolion ruthenicae*								
Anisantha tectorum (L.) Nevski			2	2	2			43
Filago minima (Sm.) Pers.		+						14
Erigeron canadensis L.				+				14
Diagnostic species for the class *Digitario sanguinalis-Eragrostietea minoris* and order *Eragrostietalia*								
Portulaca oleracea L.	+	2	+					43
Tribulus terrestris L.	+	2	+					43
Heliotropium europaeum L.	+					+		29
Eragrostis cilianensis (All.) Vign. ex Janchen	+							14
Eragrostis minor Host.						+		14
Dysphania botrys (L.) Mosyakin & Clemants		+						14
Tragus racemosus (L.) All.			1					14
Other vascular species in the communities								

Chondrilla juncea L.		2			+	2		2	57
Petrorhagia prolifera (L.) P. W. Ball & Heyw.	+			+	1	+			57
Silene conica L.	+		+		1				43
Allium scorodoprasum L.							+	+	29
Artemisia scoparia Waldst. & Kit.	+				+				29
Centaurea stoebe L.	+					+		+	29
Marrubium peregrinum L.	+						2		29
Amaranthus retroflexus L.				+					14
Centaurea solstitialis L.				+					14
Crataegus monogyna Jacq.							+		14
Crepis setosa Hall. subsp. *setosa*	+								14
Dasypyrum villosum (L.) Candargy	+								14
Bothriochloa ischaemum (L.) Keng.							1		14
Erodium ciconium (L.) L'Hér.								+	14
Gleditsia triacanthos L.							+		14
Psammophiliella muralis (L.) Ikonn.			+						14
Linaria genistifolia (L.) Mill. subsp. *genistifolia*			+						14
Malva sylvestris L.	+								14
Medicago minima (L.) Bartal.						2			14
Onopordum tauricum L.							+		14
Phleum subulatum (Savi) Asch. & Graebn.				+					14
Plantago lanceolata L. var. *eriophylla* Decne.							+		14
Polygonum arenastrum Boreau							+		14
Rumex acetosella L.								1	14
Saponaria officinalis L.						+			14
Spergularia media (L.) Presl.			2						14
Tragopogon dubius Scop.					1				14
Trifolium arvense L.			+						14
Vulpia myuros (L.) C. C. Gmel.				2					14
Mosses									
Syntrichia ruralis (Hedw.) F. Weber & D. Mohr	+		2	2					43

Fig. 3. Typical plant communities of the association *Erysimo diffusi-Cynodontetum dactylontis* near Stamboliyski town (Photo: R. Tzonev).

Such type of vegetation – species-poor ruderal communities on sandy soils - has been described only from two regions in Bulgaria. The associations *Polygono-Amaranthetum crispi* Vicol & al. 1971, *Centaureo diffusae-Berteroetum incanae* Oberd. 1957 and a community of *Polygonum arenastrum* and *Cynodon dactylon* have been found by Mucina & Kolbek (1989) in the region of Melnik town (SW Bulgaria), but on the basis of single relevés. They all belong to the alliance *Eragrostion* Tx. in Oberd. 1954. This alliance in Bulgaria also includes the association *Tribulo-Tragetum* Soó & Tímár in Tímár 1954, found by Tzonev (2009) on the biggest island in River Danube in Bulgaria: Belene Island. Some inland psammophytic, ruderal and semi-ruderal communities are widespread along Danube River, but are poorly investigated in Bulgaria. Valcheva & al. (2021a) have determined the association *Bassio laniflorae-Brometum tectorum* (Soó 1938) Bohridi 1996, with its widespread communities on the alluvial dunes in Danube's floodplains. They belong to the alliance *Bassio laniflorae-Bromion tectorum* Borhidi 1996. According to Mucina & al. (2016), this alliance is included in the order *Alysso-Sedetalia* and class *Sedo-Scleranthetea*. However, according to data from Bulgaria (Valcheva & al. 2021a), the alliance probably represents pioneer communities of the inland base-rich sandy dunes and predominantly consists of therophytes and annuals (including many ruderals), with low to average plant cover (open communities). Interpretation of such an alliance rather corresponds to definition of the class *Koelerio-Corynephoretea canescentis*.

The communities (Figs. 3 and 4) along River Maritsa differ significantly from those in the Danube's floodplains. Their ecological and floristic features assign them to the alliance *Salsolion ruthenicae* Philippi ex Oberd. 1983. According to the cited literature (Lososová & al. 2009; Borhidi 2003; Borhidi & al. 2012; Mucina & al. 2016), this alliance includes species-poor communities that develop on calcareous sandy soils, mostly after some disturbances of the original sand dune vegetation. Its typical species are: *Salsola kali* subsp. *ruthenica, Plantago arenaria, Corispermum nitidum, Bromus squarrosus, B. japon-*

Fig. 4. Communities of the association *Erysimo diffusi-Cynodontetum dactylontis* close to Lyubimets town, on sands and gravels (Photo: R. Tzonev).

Fig. 5. Typical appearance of the communities with *Plantago areanaria* and *Eryngium campestre* near Krum village, Haskovo district (Photo: R. Tzonev).

icus, Anchusa officinalis, Cynoglossum officinale, Linaria vulgaris, and *Artemisia campestris*.

At the association level, the communities in the floodplain of River Maritsa represent *Erysimo diffusi-Cynodontetum dactylontis* (Jarolímek & al. 1997) Borhidi 2003. This association includes trampling-tolerant communities of disturbed sandy grasslands, originally described as subassociation of *Conyzo-Cynodontetum dactylidi* from Slovakia (Jarolímek & al. 1997). However, *Erysimo diffusi-Cynodontetum dactylontis* differs from the latter in the presence of numerous species characteristic of the sandy grasslands (Borhidi 2003; Borhidi & al. 2012). Furthermore, most diagnostic species of *Conyzo-Cynodontetum dactylidi* are absent from it but several diagnostic species of the alliance *Salsolion ruthenicae* are present. According to

Borhidi & al. (2012), besides the dominant *Cynodon dactylon*, other typical species are: *Erysimum diffusum, Plantago arenaria, Anthemis ruthenica, Anisantha tectorum*, and *Euphorbia cyparissias*. There is not much information on the distribution of this association in other European countries. However, the communities of *Cynodon dactyon* from *Salsolion ruthenicae* described by Oprea & Sirbu (2012) are very similar in the particularities to this association. There are also many common species to both syntaxa, such as *Cynodon dactylon, Anisantha tectorum, Eragrostis minor, Heliotropium europaeum, Erigeron canadensis,* etc. Associations from *Salsolion ruthenicae* are also known to have been distributed in the Nederlands (Schaminée & al. (eds.) 1998); Germany (Berg & al. (ed.) 2004); France (de Focault 2012); Czech Republic (Lososová & al. 2009), Ukraine (Dubyna & al. 2022), and European Russia (Arpeieva 2015), but they have different floristic and ecological features as compared to the communities along River Maritsa. A similar alliance *Eragrostion* is known also from Serbia (Kojic & al. 1998), but *Salsolion ruthenicae* has not been found there so far.

Mention deserves the fact that the plant communities of *Erysimo diffusi-Cynodontetum dactylontis* along River Maritsa differ in some ways from the typical communities from Slovakia and Hungary. Their southernmost distribution and stronger bioclimatic Mediterranean influence have resulted in the participation of some southern xerophytes and Balkan endemics and sub-endemics in their floristic composition. Such species are *Poa bulbosa, Achillea pseudopectinata, Anchusa procera, Verbascum banaticum,* and *Lomelosia argentea*, which are absent from the typical communities in Central Europe. Their numbers proved sufficient to distinguish a new syntaxon on subassociation level: *poaetosum bulbosae*. The new subassociation illustrates the stronger Mediterranean influence resulting from the geographical position and remoteness of these communities from their main region of distribution in Central Europe and the influence of the surrounding xerophytic communities. Species like *Eryngium campestre* (Fig. 5) and *Bothriochloa ischaemum* have also emphasized the relationship of these semiruderal communities with the surrounding xerophytic grasslands.

Conclusion

All along River Maritsa, earlier and continuing anthropogenic activities have led to severe degradation and ruderalization, especially of the grassland vegetation. However, such wide-scale inland distribution (hundreds of kilometers of long narrow strips along both riverbanks of River Maritsa) of psamophytic, albeit actually semiruderal vegetation has been so far unknown. Although these psammophytic communities do not represent the target habitat 6220* Pseudo-steppes with grasses and annuals of the *Thero-Brachypodietea* of NATURA 2000 site BG0000578 Reka Maritsa, they represent a specific natural phenomenon that merits a more thorough study and conservation measures.

Acknowledgements. The authors wish to extend special thanks to Assoc. Prof. Ahinora Baltakova and Prof. Rossitza Kenderova (St. Kliment Ohridski Sofia University, Faculty of Geology and Geography) for their help in finding some of the literature sources and for explanation of the geological and geomorpholocigal features of the studied area.

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