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Syntaxonomical analysis of the riparian vegetation of the Porsuk River (Eskişehir-Kütahya/Turkey)

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Abstract: This study is about the classification and syntaxonomic allocation of the riparian vegetation of the Porsuk River (Eskişehir-Kütahya, western part of Central Anatolia). The Porsuk is part of the Sakarya River basin and is the longest tributary of the Sakarya River. The data were collected using the phytosociological method of Braun-Blanquet and analyzed using TWINSPAN classification and NMDS ordination. Ten syntaxa were identified, all of which are more or less widespread in the nemoral and meridional zone. The woody alluvial vegetation of the study area comprises the associations *Salicetum albae, Populetum albae*, and *Elymo-Rubetum caesii*. The riparian reed bed vegetation is represented by the associations *Phragmitetum australis*, *Schoenoplectetum tabernaemontani*, *Typhetum latifoliae*, *Typhetum angustifoliae*, *Cyperetum longi*, *Caricetum gracilis*, and *Galio palustris-Juncetum inflexi*. The community composition, though of azonal character, suggests marked influence of biogeographical and climatic sub-Mediterranean conditions.

Key words: Anatolia, helophytes, riparian, phytosociology, syntaxonomy, vegetation classification

1. Introduction

The habitats and plant communities of river alluvia are characterized by high yet fluctuating water levels and generally high soil moisture and nutrient content (Molina et al., 2004). The riparian zone forms the interface between the riverine water body and the hinterland of the river. Riparian systems constitute important wetlands.

Turkey, which in 1994 became a contracting party to the Ramsar Convention (Özen and Beklioğlu, 2007), is relatively rich in wetlands compared with Middle East countries. However, only a few studies exist on riparian vegetation in the East Mediterranean and Black Sea Region, such as those of Ocakverdi (1994), Korkmaz et al. (2011), Özen and Kılınç (1995), and Özen (1997).

The aim of this study is to classify the riparian vegetation of the Porsuk River, identify its plant communities and allocate them to syntaxa, and relate the plant associations to the characteristic geographical and environmental factors. This is the first study regarding riparian plant communities in Turkey and it is expected to contribute to the knowledge of their distribution and phytosociological relations and to encourage further research in other Turkish riverine systems.

2. Materials and methods

2.1. Study area

The Porsuk River (Porsuk Çayı) in West Anatolia is about 436 km long and is the longest tributary of the Sakarya River, one of 26 river basins in Turkey. The Porsuk River has its source in the Murat Mountain at about 1100 m a.s.l. on the Western Anatolian plateau, 17 km from the village of Tokul in the south of the province of Kütahya. After about 460 km of flow towards the east, at about 676 m a.s.l., the Porsuk River flows into the Sakarya River (near the village of Kıranharmanı) (Ocak et al., 2012). The Porsuk River has a catchment area of about 11000 km^2, which includes much of the provinces of Kütahya and Eskişehir and partially the province of Ankara. The Porsuk River, flowing along major towns and settlements, is affected by domestic (with increasing domestic waste and sewage due to population growth), agricultural, and industrial activities. As a consequence, the water quality suffers from pollution (Öztürk and Altan, 2008). The Porsuk Dam, constructed to mitigate overflow and to provide irrigation and drinking water, has modified the river regime drastically.

The research area is located in squares B2, B3, and B4 of the *Flora of Turkey* grid system (Davis, 1965–1985; Davis et al., 1988). It is in the Irano-Turanian and Mediterranean

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borderline region and under the influence of mild Mediterranean climate conditions with most precipitation in winter (Akman, 2011). The most prominent feature of the Porsuk River is its low water during summertime drought, whereas in winter the river is swollen (Figure 1).

2.2. Data collection and analysis

Seventy-three relevés were collected on the banks of the Porsuk River between 2013 and 2014, from March to August, during several field trips using the Braun-Blanquet (1932) approach and plant-cover abundance scale (+: few; 1: numerous yet < 5%; 2: 5%–25%; 3: 25%–50%; 4: 50%–75%; 5: 75%–100%) (Akman et al., 2011). In the riparian helophyte belt, the size of the quadrats was 4–16 m^2; for the riparian arboreal formations, the relevé plot size was 200 m^2. The relevés were analyzed by means of classification and ordination methods.

The abundance and cover values of taxa in the quadrats were arranged in a synthesis chart and subjected to cluster analysis by using TWINSPAN in JUICE and ordination. The cover-abundance scale values were transformed to ordinal scale. Modified TWINSPAN hierarchical classification with Sørensen dissimilarity coefficient was applied (Roleček et al., 2009). NMDS ordination was performed using R. Both analyses were run in JUICE 7.0 (Tichý, 2002) and for woody riparian and herbaceous vegetation separately.

The syntaxa were identified by comparison with literature (Seçmen and Leblebici, 1997; Poldini et al., 2011; Dakskobler and Rozman, 2013; Landucci et al., 2013; Lastrucci et al., 2014). The nomenclature of higher syntaxa follows Mucina et al. (2016); the nomenclatural correctness of plant associations was taken from secondary literature and was not verified. The nomenclature of plant taxa follows Euro+Med (2006).

3. Results and discussion

3.1. Woody riparian vegetation

Three different associations of woody riparian vegetation were identified (Table 1; Figures 2 and 3).

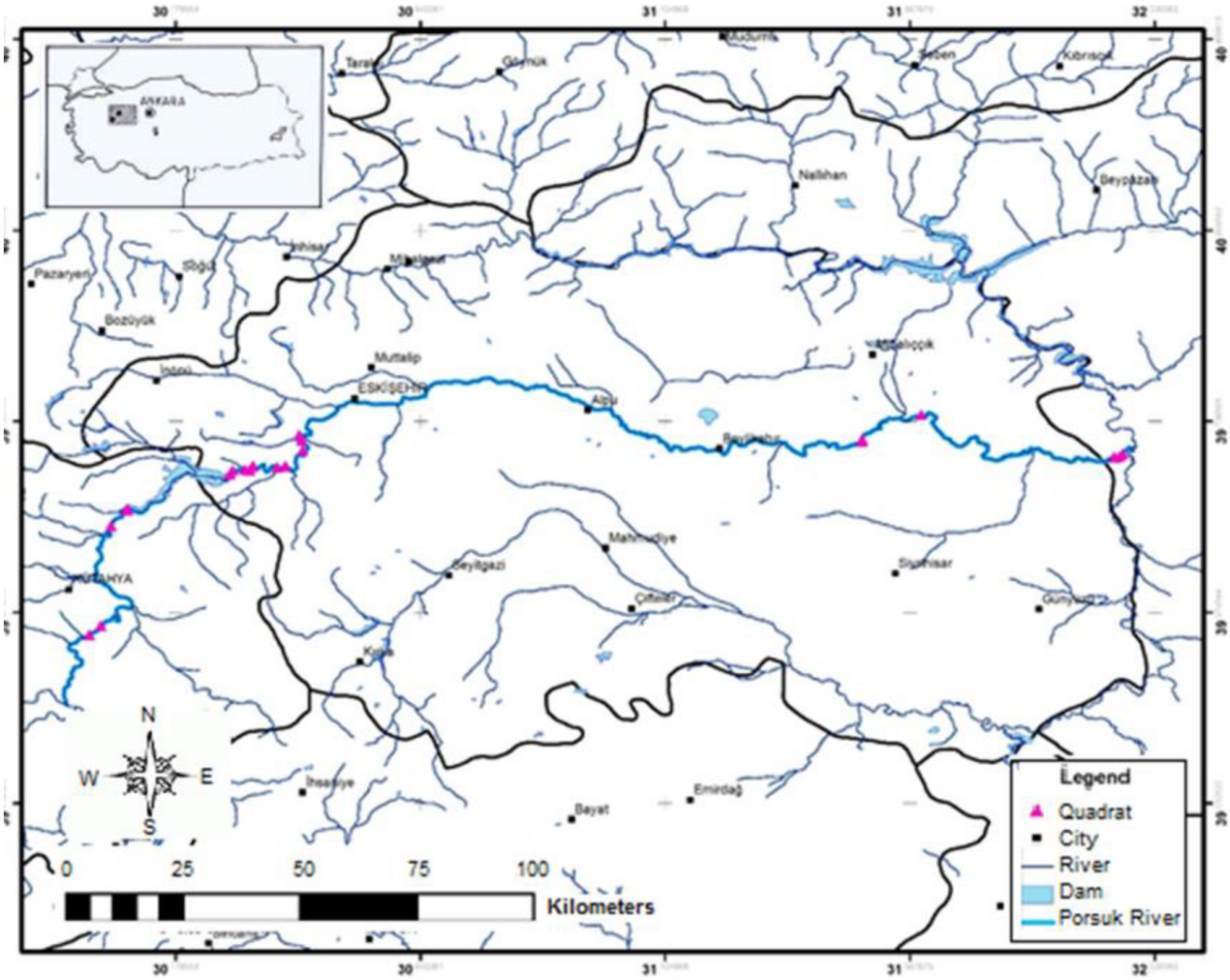

Figure 1. Map of the study area and location of quadrats.

Table 1. Synoptic table of woody riparian vegetation with percentage frequency and fidelity index phi coefficient (superscript) The shaded values indicate diagnostic species for the associations (**1.** *Elymo-Rubetum caesii*, **2.** *Salicetum albae*, **3.** *Populetum albae*). Species with frequency values of less than 25% in all associations were omitted.

Association	1	2	3
No. of relevés	5	7	20
Rubus caesius	**100** **73.8**	29 ---	15 ---
Salix alba	40 ---	**100** **61.8**	30 ---
Populus alba	. ---	14 ---	**100** **90.1**
Fraxinus angustifolia subsp. *oxycarpa*	. ---	. ---	55 67.0
Populus nigra subsp. *nigra*	20 ---	29 16.1	10 ---
Crataegus monogyna	. ---	29 ---	60 47.2
Phragmites australis	60 32.7	43 7.6	10 ---
Urtica dioica	80 73.5	. ---	15 ---
Mentha longifolia subsp. *typhoides*	. ---	29 39.0	5 ---
Elytrigia repens subsp. *repens*	. ---	57 68.6	. ---
Rumex conglomeratus	. ---	86 85.4	5 ---
Rubus hirtus	. ---	29 45.9	. ---
Rosa canina	20 ---	. ---	60 53.3
Galium aparine	60 15.5	57 11.5	30 ---
Calystegia sepium	40 25.4	29 6.7	5 ---
Rubus sanctus	. ---	14 ---	30 30.4
Verbena officinalis	. ---	29 45.9	. ---
Daucus carota	. ---	29 45.9	. ---
Medicago lupulina	20 ---	29 9.6	20 ---
Plantago lanceolata	. ---	14 16.0	10 4.9
Lotus tenuis	. ---	29 33.2	10 ---
Convolvulus arvensis	20 ---	43 34.2	5 ---
Cichorium intybus	. ---	29 33.2	10 ---
Bromus tectorum	20 ---	14 ---	30 14.8
Galium verum subsp. *verum*	20 ---	57 47.2	5 ---
Inula britannica	. ---	14 22.7	5 ---
Torilis arvensis s.l.	20 ---	29 6.7	25 ---
Equisetum ramosissimum	. ---	29 33.2	10 ---
Cirsium arvense	40 6.3	57 31.6	10 ---

3.1.1. *Elymo-Rubetum caesii*

The dominant species is *Rubus caesius*. The association formed after the destruction of riparian forest on agricultural ground and is widely yet impermanently distributed. The association occurs between 729 and 996 m and in 10°–30° inclination. In the study area, it has been identified in a narrow area in the environs of Gelinkaya, Gökçekısık, and Yunusemre.

The vegetation commonly consists of low shrub and herb layers. The shrub layer, which consists generally of *Rubus caesius* and sometimes *Rosa canina* and *Crataegus pseudoheterophylla*, covers 50%–95%. Among the herbs, *Urtica dioica*, *Galium aparine*, *Calystegia sepium*, *Lythrum salicaria*, *Rumex pulcher*, *Bromus tectorum*, *Galium verum*, *Cirsium arvense*, and *Potentilla reptans* are common.

Rubus caesius is a flood-tolerant prostrate deep-rooting pioneer shrub of compacted soils. As a substitute community after the destruction of *Salix* and *Populus* woods, *Elymo-Rubetum caesii* is now much more common than in natural riparian habitats. The association was described by Dengler (1997) and defined as a ruderal *Artemisetea* s.l. community. However, given the abundance

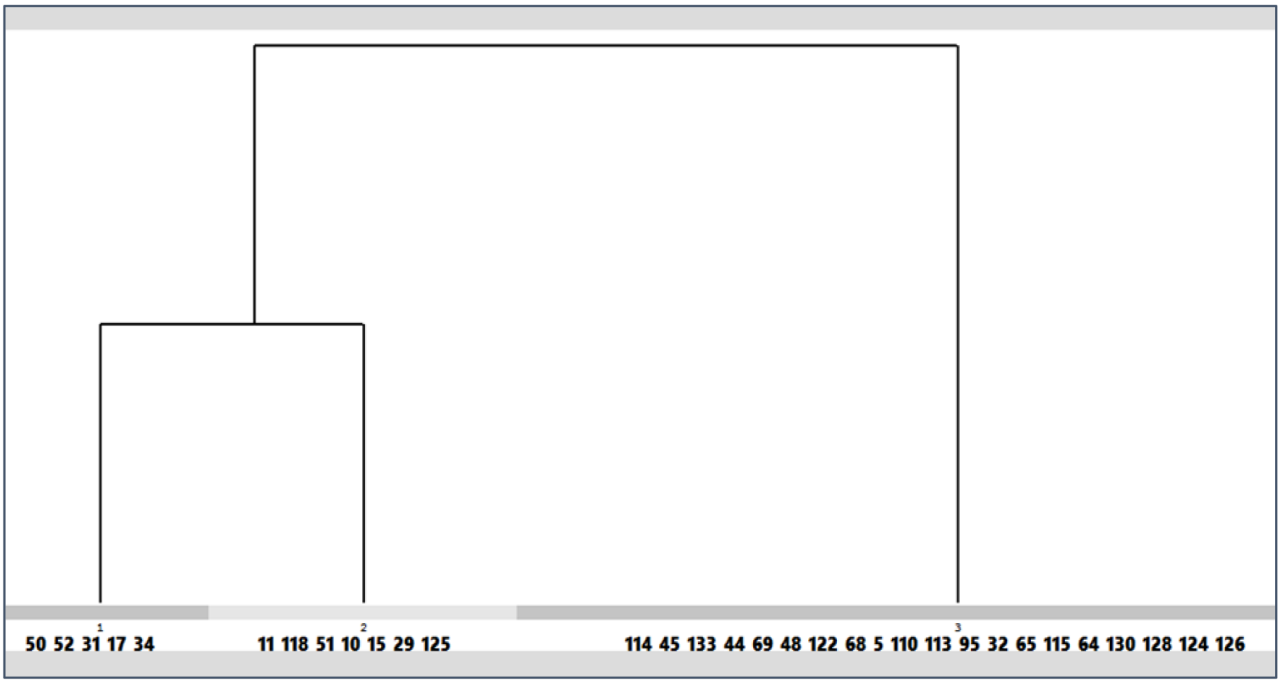

Figure 2. Dendrogram of woody riparian vegetation by TWINSPAN hierarchical clustering (from left: *Elymo-Rubetum caesii, Salicetum albae, Populetum albae*). The numbers indicated refer to relevé numbers.

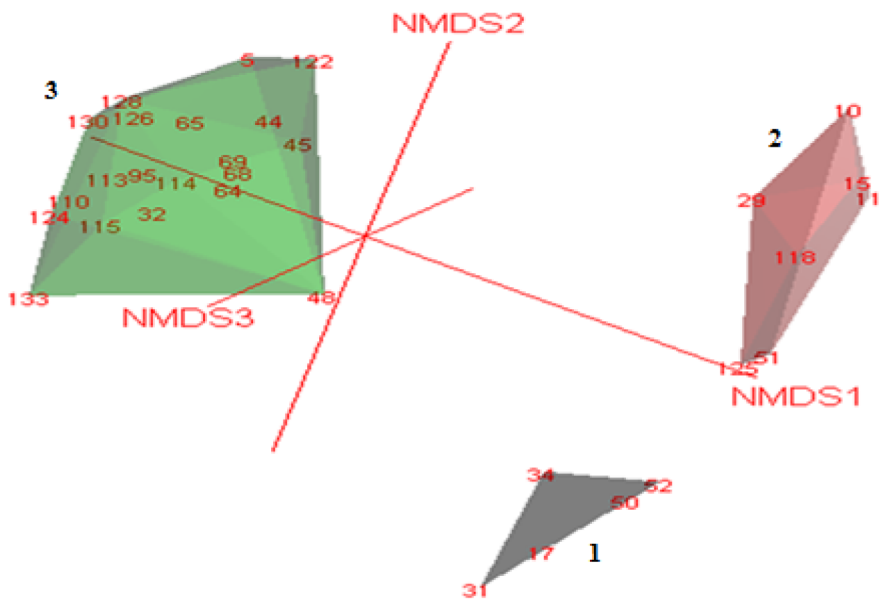

Figure 3. NMDS ordination of woody riparian vegetation (**1.** *Elymo-Rubetum caesii* **2.** *Salicetum albae* **3.** *Populetum albae*). The numbers in the diagram refer to relevé numbers.

of hygro- and nitrophilous tall herbs, we prefer to treat it as an association of *Convolvuletalia sepium*, the order being common on river banks throughout temperate Europe and the Mediterranean. Pending further studies on the riparian vegetation of the eastern Mediterranean and Near East we assign the Turkish stands of this association to *Senecion fluviatilis*, described from nutrient-rich river banks in Central Europe.

3.1.2. *Salicetum albae*

Relevés with *Salix alba* as the dominant tree were collected in gallery forest together with *Populus* species. *Salix alba* forests were found to be widespread in the study area in the environs of Kıranharmanı, Kızılinler, Gökçekısık, Yunusemre, Gelinkaya, and Yeniincesu. The records were between 713 and 986 m and at 10°–30° inclination. *Salix alba* forests exhibited tree, shrub, and herb layers. In the tree layer, besides *Salix alba*, poplars (*Populus alba*, *P. nigra*) and rarely *Pyrus communis* occurred. The shrub layer was composed of *Rubus caesius*, *Crataegus monogyna*, and *Rubus hirtus*. The rich herb layer covered generally 30%–80%, with high frequency of *Elytrigia repens* subsp. *repens*, *Convolvulus arvensis*, *Galium verum* subsp. *verum*, *G. aparine*, *Cirsium arvense*, and *Rumex conglomeratus*.

Similar forests of *Salix alba* have been recorded at Lake Kuş in western Turkey (Seçmen and Leblebici, 1997), in the Po valley in northern Italy (Poldini et al., 2011), in Slovenia (Dakskobler and Rozman, 2013), and elsewhere. The association is known by most authors as *Salicetum albae*, a very widespread nemoral riparian association that extends to the northern Mediterranean and, as shown here, to Anatolia.

3.1.3. *Populetum albae*

Populus alba, the dominant species of the association, is known to occur in most parts of Anatolia and was recorded in the Porsuk valley between 729 and 963 m and on even ground as well as embankments. This association is widespread in the research area, extending over Yunusemre, Gökçekısık, the Porsuk Dam, and between Yeniincesu and the Porsuk Dam. In the tree layer of *Populetum albae*, besides *Populus alba*, which prevails, *Salix alba*, *Fraxinus angustifolia* subsp. *oxycarpa*, *Populus nigra* subsp. *nigra*, *Populus tremula*, *Ulmus minor* subsp. *minor*, and *Acer tataricum* were found. The shrub layer comprised *Crataegus monogyna*, *Rosa canina*, and *Rubus sanctus*. There were many species in the herb layer but none with higher frequency.

In Turkey, to our knowledge, this is the first explicit phytosociological record of this association to date. Following Braun-Blanquet (1932) and Rivas-Martinez et al. (2001), the association dominated by *Populus alba* is widespread in the Mediterranean. The allocation to the order *Populetalia albae*, sub-Mediterranean and Mediterranean riparian gallery forests, is unquestionable, indicating the sub-Mediterranean climate influence in the Porsuk area. If *Populion albae*, following Mucina et al. (2016), is to be understood as an alliance of western South European distribution, our *Populus alba* woods would have to be assigned to its eastern sub-Mediterranean counterpart, *Lauro nobilis-Fraxinion angustifoliae*, although the differences are inconsistent across the wide range of the two alliances. This is why we follow Douda et al. (2016) in their recent revision of European floodplain forests, treating *Populion albae* in a wide sense comprising poplar and ash (*Fraxinus angustifolia* s.l.) forests of large river systems throughout the Mediterranean.

3.2. Herbaceous riparian vegetation

Associations on muddy ground and shallow waters constitute a major part of the Porsuk river banks. Seven plant associations were defined and are described below. The vegetation table has been subjected to cluster and ordination analyses by rearranging the Braun-Blanquet cover-abundance scale (Table 2; Figures 4 and 5).

3.2.1. *Phragmitetum australis*

The dominant and then characteristic species of the association is *Phragmites australis*. The reed, which is the most common species of the wetland area, is widespread in Turkey. The association, widespread where the Porsuk River flows at low speed, has been observed in Kıranharmanı, towards the Porsuk Dam, and near the villages of Yunusemre and Ahmetoğlulları, on plains between 674 and 911 m. The characteristic habitat of the association is not only acidic but also alkaline and mesotrophic water bodies. It was found on muddy ground in clayey, sandy, and rocky areas, in acidic as well as neutral to alkaline eutrophic and mesotrophic waters. Due to its rhizomes and clonal growth, *Pharagmites australis* forms dense stands covering 70%–100% of the quadrats. Other species are uncommon but *Calystegia sepium*, *Rumex conglomeratus*, and *Urtica dioica* were more regularly associated.

The association *Phragmitetum australis* is widely known in Turkey (e.g., Seçmen and Leblebici, 1996, 1997; Behçet 1994a; Behçet and Özgökçe, 1998; Küçüködük and Ketenoğlu, 1996) and has been recorded throughout Europe.

3.2.2. *Schoenoplectetum tabernaemontani*

The dominant and characteristic species of the association is *Schoenoplectus lacustris* subsp. *glaucus*. It is widely distributed in Turkey and in the study area it was found in the environs of Gelinkaya and around the Porsuk Dam, on flat terrain from 833 to 1000 m, both in brackish and fresh water bodies, which fall dry in summer, rich in calcium and nutrients. Among other species *Rorippa amphibia* and *Butomus umbellatus* cooccurred frequently.

Schoenoplectetum tabernaemontani constitutes helophytic vegetation with the typical reed bed physiognomy of *Phragmition communis* and *Phragmitetalia*. It occurs with high cover in constantly but shallowly inundated habitats. In Turkey, records are known from Thrace (Seçmen and Leblebici, 1991) and Erçek, Turna, and Bostaniçi lakes (Behçet, 1994b), and further into Mediterranean and temperate Europe (e.g., Minot et al., 2000, Bonanno and Lo Giudice, 2009; Lastrucci et al., 2010, 2014; Landucci et al., 2013).

Table 2. Synoptic table of herbaceous riparian vegetation with percentage frequency values and fidelity index phi coefficient (superscript). The shaded values indicate diagnostic species for the associations (**1.** *Schoenoplectetum tabernaemontani* **2.** *Typhetum angustifoliae* **3.** *Phragmitetum australis* **4.** *Cyperetum longi* **5.** *Galio palustris-Juncetum inflexi* **6.** *Typhetum latifoliae* **7.** *Caricetum gracilis*). Species with frequency values of less than 25% in all associations were omitted.

Association	1	2	3	4	5	6	7
No. of relevés	10	2	11	5	3	6	4
Schoenoplectus lacustris subsp. *glaucus*	**100** **48.5**	50 7.1	. ---	40 ---	50 7.1	. ---	50 7.1
Typha angustifolia	. ---	**100** **75.5**	. ---	. ---	33 10.5	. ---	25 2.3
Persicaria lapathifolia	. ---	100 84.2	. ---	. ---	. ---	33 14.9	. ---
Phragmites australis	20 ---	100 52.8	**100** **52.8**	. ---	. ---	17 ---	25 ---
Cyperus longus	. ---	. ---	. ---	**100** **100.0**	. ---	. ---	. ---
Juncus inflexus	. ---	. ---	18 ---	. ---	**100** **59.0**	33 ---	75 37.2
Typha latifolia	. ---	. ---	9 ---	. ---	. ---	**100** **95.0**	. ---
Carex acuta	. ---	. ---	9 ---	. ---	. ---	. ---	**100** **95.0**
Lythrum salicaria	. ---	. ---	18 ---	40 14.2	. ---	17 ---	100 70.8
Sparganium erectum subsp. *neglectum*	20 13.6	. ---	. ---	. ---	. ---	. ---	50 54.4
Eleocharis palustris	30 51.8	. ---	. ---	. ---	. ---	. ---	. ---
Lemna minor	10 ---	. ---	9 ---	. ---	. ---	33 29.0	25 18.1
Bolboschoenus spec.	20 42.0	. ---	. ---	. ---	. ---	. ---	. ---
Bolboschoenus maritimus var. *maritimus*	10 4.1	. ---	. ---	. ---	. ---	17 14.5	25 27.5
Urtica dioica	. ---	. ---	45 64.5	. ---	. ---	. ---	. ---
Mentha longifolia subsp. *typhoides*	. ---	. ---	. ---	20 ---	67 35.3	33 5.0	75 42.9
Epilobium hirsutum	. ---	. ---	. ---	. ---	. ---	33 36.9	25 24.6
Carex acutiformis	. ---	. ---	. ---	. ---	33 54.8	. ---	. ---
Rumex conglemeratus	10 ---	. ---	45 ---	100 45.3	67 17.9	67 17.9	25 ---
Galium aparine	. ---	. ---	36 57.3	. ---	. ---	. ---	. ---
Calystegia sepium	. ---	50 28.5	55 33.1	20 ---	. ---	. ---	25 3.6
Lysimachia vulgaris	. ---	. ---	. ---	60 75.0	. ---	. ---	. ---
Rorippa amphibia	90 94.1	. ---	. ---	. ---	. ---	. ---	. ---
Butomus umbellatus	60 75.0	. ---	. ---	. ---	. ---	. ---	. ---
Agrostis stolonifera	. ---	. ---	. ---	60 64.1	. ---	17 7.5	. ---
Lycopus europaeus	. ---	. ---	9 ---	40 7.0	67 30.3	33 1.2	75 37.6
Veronica anagallis-aquatica	30 16.2	. ---	9 ---	20 5.0	33 20.0	17 1.2	. ---
Althaea officinalis	. ---	. ---	. ---	40 43.2	. ---	. ---	25 22.1
Rumex pulcher	. ---	50 61.0	9 1.0	. ---	. ---	. ---	. ---
Xanthium strumarium agg.	. ---	100 95.0	9 ---	. ---	. ---	. ---	. ---
Apium nodiflorum	10 ---	. ---	9 ---	20 12.9	. ---	33 30.8	. ---
Scirpoides holoschoenus	. ---	. ---	. ---	. ---	67 64.8	. ---	25 14.4
Carex hirta	10 6.2	. ---	9 4.7	. ---	. ---	. ---	25 31.4
Daucus carota	. ---	. ---	. ---	. ---	33 54.8	. ---	. ---
Medicago lupulina	. ---	. ---	. ---	. ---	67 79.5	. ---	. ---
Plantago lanceolata	. ---	. ---	9 5.2	. ---	33 46.7	. ---	. ---
Trifolium repens	. ---	. ---	. ---	. ---	67 79.5	. ---	. ---
Trifolium pratense	. ---	. ---	. ---	. ---	33 54.8	. ---	. ---
Potentilla reptans	. ---	. ---	18 7.6	. ---	67 68.2	. ---	. ---

Table 2. (Continued).

Association	1	2	3	4	5	6	7
No. of relevés	10	2	11	5	3	6	4
Equisetum palustre	. ---	. ---	. ---	. ---	. ---	. ---	25 47.1
Juncus persicus subsp. *libanoticus*	. ---	. ---	. ---	20 42.0	. ---	. ---	. ---
Mentha aquatica	. ---	. ---	. ---	40 47.8	. ---	17 12.8	. ---
Plantago major subsp. *intermedia*	. ---	. ---	. ---	. ---	. ---	. ---	25 47.1
Lotus tenuis	. ---	. ---	. ---	. ---	67 79.5	. ---	. ---
Cichorium intybus	. ---	. ---	. ---	. ---	33 54.8	. ---	. ---
Galium verum	. ---	. ---	. ---	. ---	33 54.8	. ---	. ---
Equisetum ramosissimum	. ---	. ---	. ---	. ---	33 24.5	33 24.5	25 14.4
Torilis leptophylla	. ---	. ---	9 ---	20 15.9	33 35.0	. ---	. ---
Cirsium creticum	. ---	. ---	. ---	. ---	. ---	. ---	75 84.9
Alopecurus arundinaceus	10 6.5	. ---	. ---	. ---	33 46.0	. ---	. ---
Hordeum murinum subsp. *leporinum*	. ---	. ---	9 5.2	. ---	33 46.7	. ---	. ---
Trifolium fragiferum	. ---	. ---	. ---	. ---	67 79.5	. ---	. ---
Barbarea plantaginea	. ---	. ---	. ---	. ---	33 36.9	. ---	25 24.6
Potentilla supina	. ---	. ---	. ---	. ---	. ---	17 18.5	25 32.9
Juncus subnodulosus	. ---	. ---	. ---	. ---	. ---	. ---	25 47.1
Scrophularia umbrosa	. ---	. ---	. ---	. ---	. ---	17 18.5	25 32.9
Tripleurospermum decipiens	. ---	. ---	. ---	. ---	. ---	. ---	25 47.1
Carex hordeistichos	. ---	. ---	. ---	. ---	33 54.8	. ---	. ---
Malva neglecta	. ---	. ---	. ---	. ---	33 54.8	. ---	. ---

3.2.3. *Typhetum latifoliae*

The dominant and characteristic species of the association is *Typha latifolia*, which is almost cosmopolitan. In the research area, it has been identified in shallow muddy edges of the water bodies of the Porsuk Dam environs, near Kızılinler, Kıranharmanı, and Sazak Station, between 692 and 833 m. In the study area, many species were found to cooccur with *Typhetum latifoliae*, but none constantly.

Similar *Typha latifolia*-dominated stands have been recorded in the Lower Volga Valley (Golub et al., 1991), the Marmara Region and Turkey in general (Seçmen and Leblebici, 1996, 1997), and across Europe and the Mediterranean (e.g., Minot et al., 2000; Hanáková and Duchoslav, 2002; Otáhelóvá, 2005; Stančić, 2007, 2010; Bonanno and Lo Giudice, 2009; Lastrucci et al., 2010; Hrivnák et al., 2011; Lastrucci et al., 2012; Landucci et al., 2013).

3.2.4. *Cyperetum longi*

Cyperus longus, the dominant and characteristic species of the association, prevails in the general physiognomy. The only locality where the association has been recorded in the study area is in the Kütahya-Uşak city environs, on even ground between 963 and 982 m. It grows in eutrophic marshes and along rivers, ditches, and canals in soils wet throughout the year. *Cyperus longus* is widespread in the Mediterranean, in Turkey, and beyond in Southwest Asia. Among the more commonly cooccurring species in the Porsuk valley are *Lysimachia vulgaris*, *Lythrum salicaria*, and *Rumex conglemeratus*.

While this appears to be the first record of the association in Turkey, it is by no means rare in southern Europe according to the literature (Jasprica et al., 2003; Stančić, 2007; Bonanno and Lo Giudice, 2009; Lastrucci et al., 2010, 2012; Landucci et al., 2013). Most authors assigned *Cyperetum longi* to the *Magnocaricetalia* sedge bed vegetation of *Phragmito-Magnocaricetea*.

3.2.5. *Caricetum gracilis*

Carex acuta is the dominant and characteristic species of this association, which is represented in our dataset by only 4 relevés from around 830 m in Kızılinler and partially the Porsuk Dam. Being common in temperate Europe, *Carex acuta* occurs also in North and East Anatolia and more rarely in southern Turkey, further in Northwest Africa, the Near East, the Caucasus, and West Siberia. In the Porsuk valley, it is found on the shallow banks where the water is relatively stagnant, on mesotrophic and eutrophic soils rich

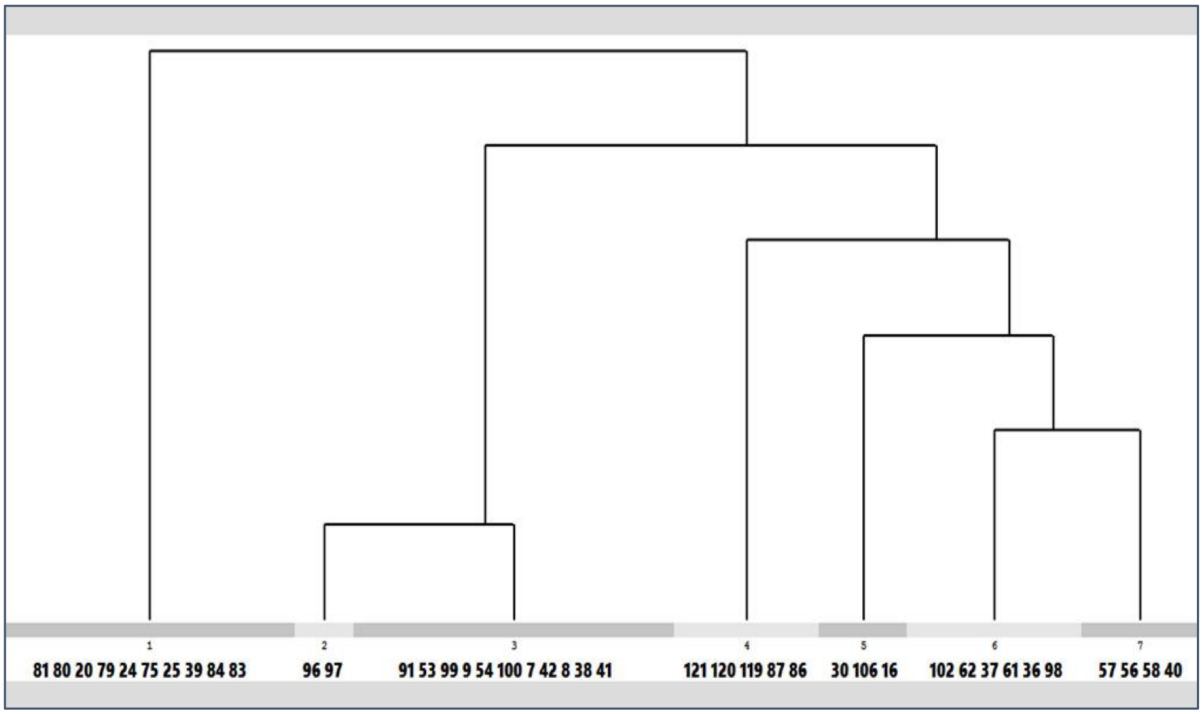

Figure 4. Dendrogram of herbaceous riparian vegetation by TWINSPAN hierarchical clustering (from left: *Schoenoplectetum tabernaemontani, Typhetum angustifoliae, Phragmitetum australis, Cyperetum longi, Galio palustris-Juncetum inflexi, Typhetum latifoliae, Caricetum gracilis)*. The numbers indicated refer to relevé numbers.

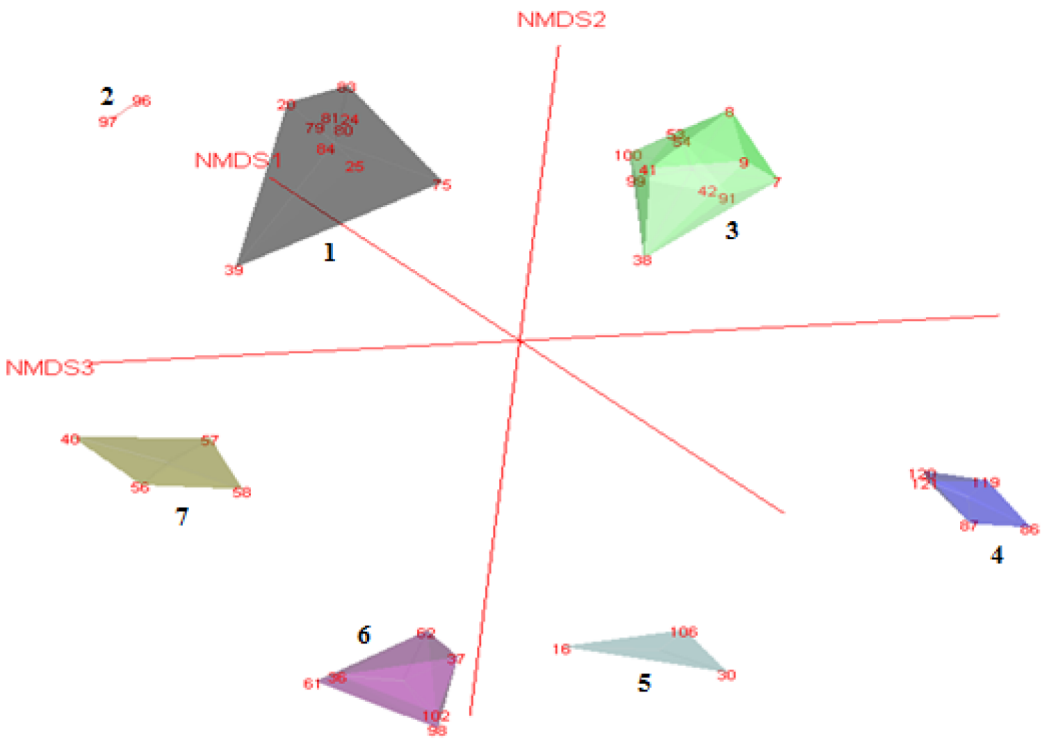

Figure 5. NMDS ordination of herbaceous riparian vegetation (**1.** *Schoenoplectetum tabernaemontani* **2.** *Typhetum angustifoliae* **3.** *Phragmitetum australis* **4.** *Cyperetum longi* **5.** *Galio palustris-Juncetum inflexi* **6.** *Typhetum latifoliae* **7.** *Caricetum gracilis*). The numbers indicated refer to relevé numbers.

in organic material. Among the more common companion species are *Lycopus europaeus*, *Lythrum salicaria*, *Mentha longifolia* subsp. *typhoides*, and *Juncus inflexus*.

In comparison with the vegetation records of Seçmen and Leblebici (1997), Hanáková and Duchoslav (2002), Hrivnák (2004), Hrivnák et al. (2011), Landucci et al. (2013), and Golub et al. (1991) suggested that *Caricetum gracilis* is an association of *Magnocaricion gracilis*.

3.2.6. *Galio palustris-Juncetum inflexi*

Juncus inflexus, the dominant and characteristic species, determines the general physiognomic structure of the association. It is represented in the research area by only 3 relevés between Kızılinler and Yeniincesu-Porsuk Dam around 830 m, on periodically inundated sandy and muddy ground near rivers and lake shores. *Juncus inflexus* is widespread over Eurasia and Africa and introduced elsewhere. *Mentha longifolia* subsp. *typhoides*, *Rumex conglomeratus*, *Trifolium repens*, and *Trifolium fragiferum* commonly accompany *Juncus inflexus*.

After comparison of the association with the studies of Seçmen and Leblebici (1997), Minot et al. (2000), Groza et al. (2007), Lastrucci et al. (2012), and Landucci et al. (2013), it was concluded that this association, named by Venanzoni and Gigante (2000) as *Galio palustris-Juncetum inflexi*, is best assigned to the temporarily flooded nutrient-rich riparian alluvia meadow-fringe plant communities of the *Mentho longifoliae-Juncion inflexi*, an alliance recently assigned to the *Filipendulo ulmariae-Lotetalia uliginosae* (Mucina et al., 2016), but perhaps better accommodated in *Holoschoenetalia*.

3.2.7. *Typhetum angustifoliae*

This association of *Typha angustifolia* as its dominant and characteristic species was recorded in only 2 relevés from the village environs of Ahmetoğulları and Kıranharmanı. *Typha angustifolia* is almost cosmopolitan and *Typhetum angustifoliae* is known in Turkey from Thrace and North and Central Anatolia. The association occurs on muddy shores, in mesotrophic and eutrophic waters rich in organic sediments less deep than 1 m. The dense stands of *Typha angustifolia* cover up to 100%, with few other species associated.

Stands similar to those of the Porsuk valley have been recorded from the shores of Akşehir Lake (Küçüködük and Çetik, 1984), the Seydişehir swan bog (Ocakverdi, 1984), western Anatolia (Seçmen and Leblebici, 1988), Beyşehir Lake (Küçüködük and Ketenoğlu, 1996), Tekke Lake and Sapanca Lake (Sakarya) (Seçmen and Leblebici, 1996), and further all over Europe (Golub et al., 1991; Hanáková and Duchoslav, 2002; Jasprica et al., 2003; Otáhelóva, 2005; Stančić, 2007; Bonanno and Lo Giudice, 2009; Landucci et al., 2013). It is one of the most widespread associations in the Turkish wetlands. It is generally treated in the alliance *Phragmition communis*.

3.3. Syntaxonomical scheme

Salicetea purpureae Moor 1958
  Salicetalia purpureae Moor 1958
    Salicion albae Soó 1951
      Salicetum albae Issler 1926
Alno glutinosae-Populetea albae P. Fukarek et Fabijanić 1968
  Populetalia albae Br.-Bl. ex. Tchou 1948
    Populion albae Br.-Bl. ex. Tchou 1948
      Populetum albae Br.-Bl. ex Tchou 1948
Galio-Urticetea Passarge 1967
  Convolvuletalia sepium Tx. ex Moor 1958
    Senecion fluviatilis Tx. ex Moor 1958
      Elymo-Rubetum caesii Dengler 1997
Phragmito-Magnocaricetea Klika in Klika et Novák 1941
  Phragmitetalia Koch 1926
    Phragmition communis Koch 1926
      Phragmitetum australis Savič 1926
      Schoenoplectetum tabernaemontani Soó 1947
      Typhetum latifoliae Nowiński 1930
      Typhetum angustifoliae Pignatti 1954
  Magnocaricetalia Pignatti 1953
    Magnocaricion gracilis Géhu 1961
      Cyperetum longi Micevski 1957
      Caricetum gracilis Savič 1926
Molinio-Arrhenatheretea Tx. 1937
  Holoschoenetalia Br.-Bl. ex. Tchou 1948
    Mentho longifoliae-Juncion inflexi T.Müller et Görs ex de Foucault 2009
      Galio palustris-Juncetum inflexi Venanzoni et Gigante 2000

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References

Akman Y (2011). İklim ve Biyoiklim. Ankara, Turkey: Palme Yayıncılık (in Turkish).

Akman Y, Ketenoğlu O, Kurt F (2011). Vejetasyon Ekolojisi ve Araştırma Metodları. Ankara, Turkey: Palme Yayıncılık (in Turkish).

Behçet L (1994a). Van Gölü makrofitik vejetasyonunun fitososyolojik yönden araştırılması. Turk J Bot 18: 229-243 (in Turkish).

Behçet L (1994b). Erçek, Turna ve Bostaniçi (Van) göllerinin vejetasyonu. Turk J Bot 18: 305-312 (in Turkish).

Behçet L, Özgökçe F (1998). The vegetation of some lakes in East Anatolia (Turkey). Bulletin of Pure and Applied Sciences 17B: 1-15.

Bonanno G, Lo Giudice R (2009). Vegetation of the Acquicella stream, urban water course of Catonia (Sicily, South Italy). Webbia 64: 213-234.

Braun-Blanquet J (1932). Plant Sociology. New York, NY, USA: McGraw-Hill.

Dakskobler I, Rozman A (2013). Phytosociological analysis of riverine forests along the Sava Bohinjka, Radovna, Ucja and Slatenik Rivers in Northwestern Slovenia. Folia Biologica et Geologica 54: 37-106.

Davis PH (1965–1985). Flora of Turkey and the East Aegean Islands. Vols. 1–9. 1st ed. Edinburgh, UK: Edinburgh University Press.

Davis PH, Mill, RR, Tan K (1988). Flora of Turkey and the East Aegean Islands (Suppl. 1), Vol. 10. 1st ed. Edinburgh, UK: Edinburgh University Press.

Dengler J (1997). Gedanken zur synsystematischen Arbeitsweise und zur Gliederung der Ruderalgeseilschaften (*Artemisietea vulgaris* s. l.). Mit der Beschreibung des *Elymo-Rubetum caesii* ass. nova. Tuexenia 17: 251-282 (in German).

Douda J, Boublík K, Slezák M, Biurrun I, Nociar J, Havrdová A, Doudová J, Aćić S, Brisse B, Brunet J et al. (2016). Vegetation classification and biogeography of European floodplain forests and alder carrs. Appl Veg Sci 19: 147–163.

Euro+Med (2006-). Euro+Med PlantBase - The Information Resource for Euro-Mediterranean Plant Diversity. Available online at http://ww2.bgbm.org/EuroPlusMed/ (accessed 25 March 2017).

Golub T, Losev A, Mirkin U (1991). Aquatic and hygrophytic vegetation of the Lower Volga valley. Phytocoenologia 20: 16-63.

Groza G, Beldean M, Mihai G (2007). Bio-economic analysis of the flora and vegetation of the grasslands of the Meşendorf ecological farm (Braşov County, Romania). Bulletin 63: 156-162.

Hanáková P, Duchoslav M (2002). Vegetace rákosin a vysokých ostřic ctř. *Phragmito-Magno-Carictea* rivy Maravy v Hornomoravskēm ūvalu. Čas Slez Muz Opava (A) 51: 243-258 (in Czech).

Hrivnák R (2004). The plant communities of *Phragmitetalia* in the catchment area of the Ipeľ river (Slovakia and Hungary) 2. Tall-sedge dominated wetlands (*Magnocaricion elatae*). Biologia 59: 457-476.

Hrivnák R, Kochjanová J, Otáhelóvá H (2011). Vegetation of aquatic and marshland habitats in the Orava region, including the first records of *Potametum alpini*, *Potametum zizii* and *Ranunculo-Juncetum bulbosi* in the territory of Slovakia. Biologia 66: 1-26.

Jasprica N, Caric M, Batistic M (2003). The marshland vegetation (*Phragmito-Magnocaricetea, Isoëto-Nanojuncetea*) and hydrology in the Hutavo Blato Natural Park (Neretura River Delta, Bosnia and Herzegovina). Phyton 43: 281-294.

Korkmaz H, Engin A, Kutbay HG, Yalçın E (2011). A syntaxonomical study on the scrub, forest, and steppe vegetation of the Kızılırmak valley. Turk J Bot 35: 121-165.

Küçüködük M, Çetik AR (1984). Akşehir Gölü ve kıyılarının flora ve vejetasyonu. Selçuk Üniversitesi Fen-Edebiyat Fakültesi Fen Dergisi 3: 73-90 (in Turkish).

Küçüködük M, Ketenoğlu O (1996). Beyşehir Gölü'nün makrofitik vejetasyonu. Turk J Bot 20: 189-198 (in Turkish).

Landucci F, Gigante D, Venanzani R, Chytrý M (2013). Wetland vegetation of the class *Phragmito-Magno-Caricetea* in Central Italy. Phytocoenologia 43: 67-100.

Lastrucci L, Bonari G, Angiolini C, Casini F, Giallonardo T, Gigante D, Landi M, Landucci F, Venanzoni R, Vicioni D (2014). Vegetation of Lakes Chiusi and Montepulciano (Siena, Central Italy): updated knowledge and new discoveries. Plant Sociology 51: 29-55.

Lastrucci L, Landi M, Angiolini C (2010). Vegetation analysis on wetlands in a Tuscan agricultural landscape (central Italy). Biologia 65: 54-68.

Lastrucci L, Landucci F, Gonnelli V, Boracco R, Foggi B, Venanzoni R (2012). The vegetation of the upper and middle River Tiber (Central Italy). Plant Sociology 49: 29-48.

Minot JM, Carreras J, Carrilloe E, Vigo J (2000). Syntaxonomic conspectus of the vegetation of Catolonia and Andorra. I: Hygrophilous herbaceous communities. Acta Botanica 46: 191-237.

Molina JA, Pertíñez C, Díez A, Casermeiro MÃ (2004). Vegetation composition and zonation of a Mediterranean braided river floodplain. Belg J Bot 137: 140-154.

Mucina L, Bültmann H, Dierßen K, Theurillat JP, Raus T, Čarni A, Šumberová K, Willner W, Dengler J, Gavilán R et al. (2016). Vegetation of Europe: hierarchical floristic classification system of vascular plant, bryophyte, lichen, and algal communities. Appl Veg Sci 19 (Suppl. 1): 3-264.

Ocak A, Orhan A, Özdeniz E (2012). Porsuk Çayı ve çevresinin florası. Biological Diversity and Conservation 5: 41-52 (in Turkish).

Ocakverdi H (1984). Seydişehir Kuğulu Bataklığının (Konya) Fitososyolojik yönden incelenmesi. Selçuk Üniversitesi Fen-Edebiyat Fakültesi Fen Dergisi 3: 223-235 (in Turkish).

Ocakverdi H (1994). Akyaka, Arpaçay, Melikköy ve Değirmenköprüköy yaylaları (Kars) ile Sovyet sınırı arasında kalan bölgenin bitki sosyolojisi ve ekolojisi yönünden araştırılması. Turk J Bot 18: 245-265 (in Turkish).

Otáhelóvá H (2005). Aquatic macrophytes vegetation of the gravel-pit lakes in the Borska nizika Lowland. Bull Slav Bot Spolocn 27: 151-156.

Özen F (1997). Balıkesir Değirmenboğazı ve çevresinin vejetasyonu. OMÜ Fen Edebiyat Fakültesi Fen Dergisi 8: 54-76 (in Turkish).

Özen A, Beklioğlu M (2007). Sulakalanlarla İlgili Temel Bilgiler. Sulakalan Yönetim Planlaması Rehberi. Ankara, Turkey: Doğa Koruma ve Milli Parklar Genel Müdürlüğü Kuş Araştırmaları Derneği (in Turkish).

Özen F, Kılınç M (1995). Alaçam-Gerze ve Boyabat-Durağan arasında kalan bölgenin vejetasyonu: I-Maki, Frigana, Dere ve Step vejetasyonları. Turk J Bot 19: 65-86 (in Turkish).

Öztürk R, Altan T (2008). Porsuk Çayı çevre sorunları ve bunların çözümlenmesinde havza yönetimi önerileri. Çukurova Üniversitesi Fen Bilimleri Enstitüsü 17: 79-89 (in Turkish).

Poldini L, Vidalı M, Ganis P (2011). Riparian *Salix alba*: Scrubs of the Po lowland (N-Italy) from an European perspective. Plant Biosystems 145 (Suppl.): 132-147.

Rivas-Martínez S, Fernández-González F, Loidi J, Lousã M, Penas A (2001). Syntaxonomical checklist of vascular plants communities of Spain and Portugal to association level. Itinera Geobotanica 14: 5-341.

Roleček J, Tichý L, Zelený D, Chytrý M (2009). Modified TWINSPAN classification in which the hierarchy respects clustery heterogenety. Journal of Vegetation Science 20: 596-602.

Seçmen Ö, Leblebici E (1988). Batı Anadolu Sucul Vejetasyonu. IX. Ulusal Biyoloji Kongresi. 21-23 Eylül 1988. Cilt 3: 369-381 (in Turkish).

Seçmen Ö, Leblebici E (1991). Trakya'nın sucul ve bataklık bitki örtüsü. Turk J Bot 15: 142-165 (in Turkish).

Seçmen Ö, Leblebici E (1996). Marmara Bölgesi Sulak Alanlarının Bitki Örtüsü. Turk J Bot 20: 171-187 (in Turkish).

Seçmen Ö, Leblebici E (1997). Türkiye Sulak Alan Bitkileri. İzmir: Ege Üniversitesi Fen Fakültesi Yayınları (in Turkish).

Stančić Z (2007). Marshland vegetation of the class *Phragmito-Magnocaricetea* in Croatia. Biologia 62: 297-314.

Stančić Z (2010). Marshland vegetation of the class *Phragmito-Magnocaricetea* in northwest Crotia (Krapina river valley). Biologia 65: 39-53.

Tichý L (2002). JUICE, software for vegetation classification. Journal of Vegetation Science 13: 45-453.

Venanzoni R, Gigante D (2000). Contributo alla conoscenza della vegetazione degli ambienti umidi dell'Umbria (Italia). Fitosociologia 37: 13-63 (in Italian).