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The phytosociology, ecology, and plant diversity of new plant communities in Central Anatolia (Turkey)

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Key words: Aksaray, Irano-Turanian, Niğde, steppe, plant community, riparian vegetation, syntaxonomy.

Ključne besede: Aksaray, irano-turanska, Niğde, stepa, rastlinska združba, obrečna vegetacija, sintaksonomija.

Abstract

The Central Anatolian vegetation has diverse site conditions and small-scale plant diversity. For this reason, identification of plant communities is important for understanding their ecology and nature conservation. This study aims to contribute the syntaxonomical classification of the Central Anatolian vegetation. The study area is situated among Güzelyurt, Narköy, and Bozköy (Niğde) in the east of Aksaray province of Central Anatolia in Turkey. The vegetation data were collected using the phytosociological method of Braun-Blanquet and classified using TWINSPAN. The ecological characteristics of the units were investigated with Detrended Correspondence Analysis. Three new plant associations were described in the study. The steppe association was included in *Onobrychido armenae-Thymetalia leucostomi* and *Astragalo microcephali-Brometea tomentelli*. The forest-steppe association was classified under *Quercion anatolicae* in *Quercetea pubescentis*. The riparian association is the first poplar-dominated one described in Turkey and, classified under *Alno glutinosae-Populetea albae* and its alliance *Populion albae.*

Izvleček

Vegetacijo Srednje Anatolije najdemo na raznolikih rastiščih in je na majhnem območju vrstno zelo pestra. Identifikacija rastlinskih združb je zato pomembna za razumevanje njihove ekologije in naravovarstva. Raziskava je prispevek k sinataksonomski klasifikaciji vegetacije Srednje Anatolije. Preučevano območje obsega površino med mesti Güzelyurt, Narköy in Bozköy (Niğde) na vzhodu province Aksaray v Srednji Anatoliji v Turčiji. Vegetacijo smo preučevali s fitocenološko metodo po Braun-Blanquetu in klasificirali z metodo TWINSPAN. Ekološke značilnosti vegetacijskih tipov smo preučevali z Korespondenčno analizo z odstranjenim trendom (DCA). Opisali smo tri nove asociacije. Stepsko asociacijo smo vključili v red *Onobrychido armenae-Thymetalia leucostomi* in razred *Astragalo microcephali-Brometea tomentelli*. Gozdno-stepsko asociacijo smo uvrstili v zvezo *Quercion anatolicae* in razred *Quercetea pubescentis*. Obrečna vegetacija predstavlja prvo asociacijo, opisano v Turčiji, v kateri dominirajo topoli. Uvrstili smo jo v razred *Alno glutinosae-Populetea albae* in zvezo *Populion albae*.

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Introduction

The vast plains of Central Anatolia, which is surrounded by high mountain ranges from the south and the north, and the Anatolian Diagonal from the east, are covered with steppe vegetation below 1000–1200 m a.s.l. Some volcanic mountains rise up almost 4000 m in the eastern part of the Inner Anatolia. The forest-steppes occur between 1200–2000 m a.s.l. of these mountains and the subalpine steppe vegetation also follows above this dry forest zone (Kurt et al. 2006, Atalay et al. 2014). Central Anatolia is also a very rich region in terms of wetlands which harbour many plant and animal species. Most of these wetlands are salty due to the location of the region in closed basins and evaporation more than precipitation (Langbein 1961, Seçmen & Leblebici 1997). These areas are covered by halophytic vegetation dominated by the species of *Salicornia* L., *Halocnemum* M. Bieb, and *Limonium* Mill., while riparian and hydrophytic species, such as *Salix* L., *Populus* L., *Schoenoplectus* (Rchb.) Palla, *Phragmites* Adans., occur in non-saline habitats. The Cenral Anatolian steppe is dominated by cushion-forming plants such as *Astragalus* L., *Acantholimon* L., *Thymus* L., *Artemisia* L., gramineous species, and dwarf shrubs under harsh continental climate, which is cold in winters and dry during summers with 300 mm/year precipitation, while the forest-steppes in the region are composed of xerophytic oaks such as *Q. cerris* L., *Q. ithaburensis* subsp. macrolepis (Kotschy) Hedge & Yalt., and *Q. pubescens* Willd., junipers (*J. excelsa* M. Bieb., *J. foetidissima* Willd.), and pine (*P. nigra* J.F. Arnold) (Kürschner & Parolly 2012). The understory of the forest-steppes is rich in steppe species due to semi-open canopy, thus they have the mosaic-type aspect (Uğurlu et al. 2012). Further, the Central Anatolian steppes and forest-steppes host a high diversity of life-forms, rare, endemic, and threatened species due to their high structural heterogeneity and diverse topography (Kürschner & Parolly 2012, Ambarlı et al. 2016).

The steppes and forest-steppes are included in the Irano-Anatolian biodiversity hotspot in Turkey, which is one of the seven identified grassland hotspots of the Palearctic realm (Dengler et al. 2014, Ambarli et al. 2016). The number of species in the region is more than 2,000 and the endemism rate is about 30% which is a remarkably

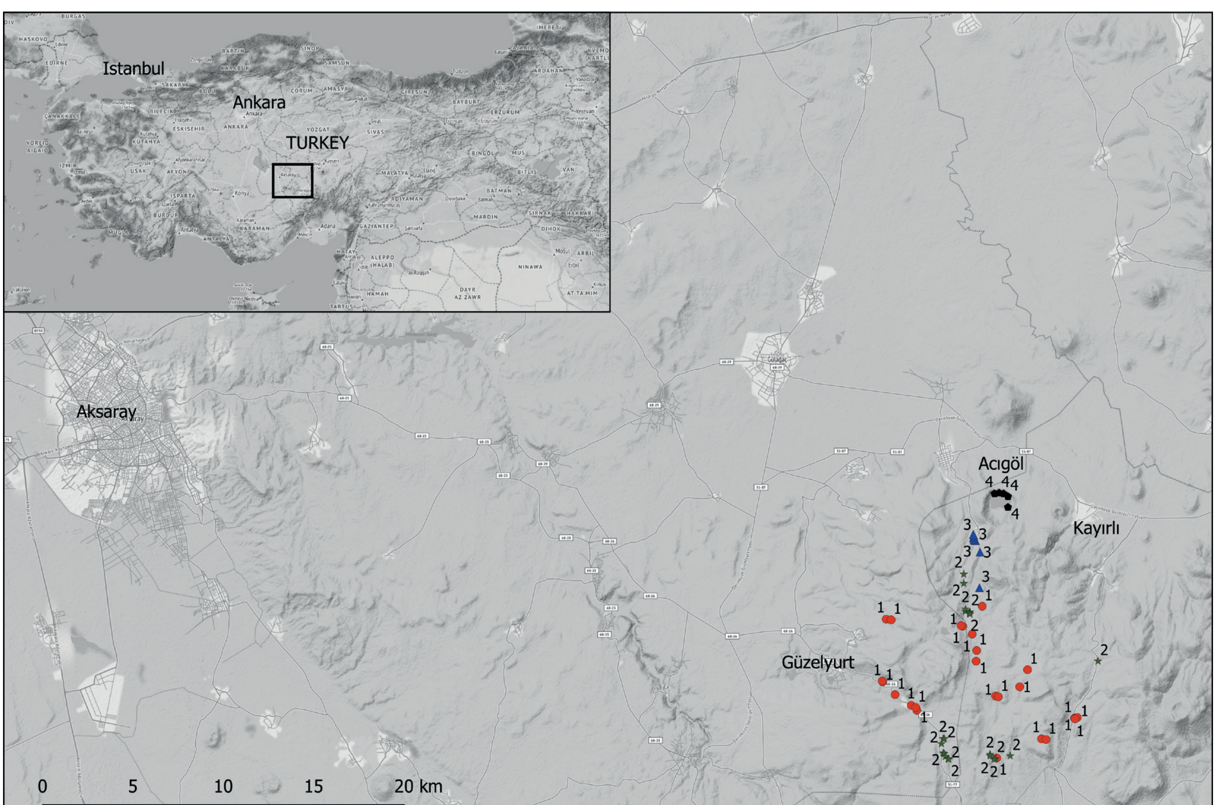

Figure 1: The study area with points of relevé locations (numbers indicate the communities; *1. Astragaletum plumoso-microcephalii; 2. Cotoneastro nummulariae-Quercetum pubescentis; 3. Pastinaco sativae-Populetum nigrae; 4. Phragmites australis*).

Slika 1: Preučevano območje s točkami, ki predstavljajo lokacije popisov (številke predstavljajo združbe; *1. Astragaletum plumoso-microcephalii; 2. Cotoneastro nummulariae-Quercetum pubescentis; 3. Pastinaco sativae-Populetum nigrae; 4. Phragmites australis*).

high rate as compared to the biological diversity in other countries of the temperate zone (Şekercioğlu et al. 2011). The high species richness results from its biological and evolutionary status that serve a passage of migration and a refugium of plants and animals in the past glacial periods (Bilgin 2011). In addition to being an important because of the high biodiversity, increasing anthropogenic pressures make Central Anatolian vegetation is a fairly sensitive ecosystem (Kaya & Raynal 2001, Tavşanoğlu 2017). It was estimated that more than 44% of the natural steppe and forest-steppe area of Turkey have been mainly converted into croplands (Ambarlı et al. 2016). The Central Anatolian wetlands are also particularly have been most affected by the misapplication of water resource policies of Turkey. Thus, both terrestrial habitats and wetland ecosystems in the Central Anatolia have been under human disturbance and this is a serious threat for many species. For this reason, the phytosociological data on such highly diverse vegetation can serve a good basis for subsequent assessment and monitoring of biodiversity (Dengler et al. 2008). In this context, the syntaxonomical classification condensing compositional and structural information within a hierarchical system indicates historical, sociological, and habitat factors influencing the actual and potential vegetation (Blasi & Burrascano 2013).

The steppe and forest-steppe vegetation have been phytosociologically well studied in Central Anatolia (Kurt et al. 2006, Ketenoğlu et al. 2010). First contribution on the studies of steppe vegetation in Central Anatolia were made by Zohary (1973), whose classification was more or less based on the dominance principle (Kürschner & Parolly 2012). More detailed phytosociological studies on steppe and forest-steppe, following the Braun-Blanquet (1964) approach, were performed by Akman (1974, 1990), Akman et al. (1984, 1986, 1994, 1996), Aydoğdu et al. (1994, 1999, 2004), Yurdakulol et al. (1990), Ketenoğlu et al. (1996), Hamzaoğlu (2005), whereas a few phytosociological studies were conducted on wetland vegetation in Turkey (Akman et al. 1993, Seçmen & Leblebici 1996, Seçmen & Leblebici 1997, Kutbay et al. 1998, Karaömerlioğlu 2007, Kavgaci et al. 2011, Korkmaz et al. 2012, Özdeniz et al. 2016). However, there are still gaps concerning phytosociological data of steppe, forest-steppe, and wetland communities in Central Anatolia due to unsurveyed areas. According to Uğurlu et al. (2012), *Quercus*-dominated woodlands with junipers (*J. excelsa* M. Bieb., *J. oxycedrus* L.) in forest-steppe habitats of Central Anatolia were poorly studied. For this reason, we aimed to fill at least one of these gaps by contributing to the syntaxonomy, ecology, and diversity of the steppe, forest-steppe, and wetland communities in the southeastern part of Central Anatolia. Furthermore, we expect to have more exhaustive information about these communities in floristic and ecological aspect by means of this study that will provide an inventory of vegetation for the Natura 2000 ecological network.

Methods

Study Area

The study area located between Aksaray and Niğde provinces of Central Anatolia. The area is surrounded by Güzelyurt village (Aksaray) in the west, Narköy village (Niğde) in the north, Bozköy village (Niğde) in the south, and Kayırlı village (Niğde) in the east (Figure 1). The altitude of the study area varies between 1400 m and 1900 m a.s.l. The study area is situated in the Irano-Turanian phytogeographic region, which is the richest region in Anatolia in terms of plant diversity and endemic plants. It remains in B5 square according to Davis's grid system (Davis 1965–1985).

The area is composed of upper Miocene-Pliocene volcanic rocks and quaternary deposits. The bedrock of the area is andesite, basalt, tuff, rhyolite, and ignimbrite. The main soil types of the study area are brown non-calcareous soils and brown forest soils (Dizdar 2003). A lower semi-arid and extremely cold Mediterranean climate prevails in the region with, cold winters with frost periods, and hot and arid summers. The average annual precipitation of the region varies between 341.1 mm and 346 mm, the average annual temperature is between 11.2 °C and 12.1 °C, and mean of the maximum temperatures of the hottest month 30.6 °C and 29.5 °C (Table 1).

Table 1: Bioclimatic synthesis.
Tabela 1: Bioklimatski dejavniki.

Station	P (mm)	M (°C)	m (°C)	PE	Q	S	Prep. regime	Bioclimate type
Niğde	341.1	29.5	-4.6	34.9	35	1.2	Sp. W. A. Su.	Lower semi-arid very cold Mediterranean climate
Aksaray	346	30.6	-3.7	37.5	35.2	1.2	Sp. W. A. Su.	Lower semi-arid very cold Mediterranean climate

P: Annual mean precipitation (mm); M: Mean of the maximum temperatures of the hottest month (°C); m: Mean of the minimum temperatures of the coldest month (°C); PE: Summer precipitation (mm); S: Drough index S = PE / M; Q: Emberger rainfall index Q = 2000 × P / (M + m + 546.6) (M-m)

Data collection

Steppe, forest-steppe, riparian, and shoreline communities were studied using the Braun-Blanquet method (Braun-Blanquet 1964) and all relevés were sampled from floristically and physiognomically homogenous habitats (Braun-Blanquet 1964) during vegetation period of the summer of 2016. The Minimal Area Method (Braun–Blanquet 1964) was used to determine relevé sizes; as 64 m^2 for steppe vegetation, 284 m^2 for forest-steppe vegetation, and 25 m^2 for riparian and wetland vegetation**.** A complete list of vascular plants and their cover-abundance values on a seven-degree scale were recorded (r, +, 1, 2, 3, 4 and 5). "Flora of Turkey and the Aegean Islands" and "The Checklist of the Flora of Turkey-Vascular Plants" were referred to identify the specimens recording (Davis 1965–1985, Güner et al. 2012). All specimens were preserved at the Herbarium of Ankara University (ANK) and Aksaray University (AKSU). Climatic data were obtained from the website of General Directorate of Meteorological Service (MGM 2017) and bioclimatic synthesis of the study area was determined by Akman & Daget (1971). Soil samples were taken from various sample plots representing the different plant formations and from depths ranging between 0 and 30 cm. The measurements of particle size (Richards 1954), organic matter (Walkley & Black 1934), nitrogen (Kjeldahl 1883), potassium (Ammonium acetate), phosphorous spectrophotometrically (Olsen 1954), lime-Scheibler method (Jackson 1958), salt, pH (pH meter), EC (EC meter) were performed.

Data Analysis

Vegetation data and 69 sample plots in total were stored in TURBOVEG database (Hennekens & Schaminée 2001) and transferred to JUICE (Tichý 2002). The relevés were classified utilizing the TWINSPAN (Cut levels 0, 2, 5, and 25) (Hill 1979).

The potential annual radiation index (PDIR) and heat-load were calculated using the latitude, slope inclination, and aspect of the relevés using equation proposed by McCune (2007). The Ellenberg Indicator Values (EIVs) of the species were generated by Ellenberg Indicator Values, which were prepared for the Flora Europea by Pignatti (2005). EIVs were arranged for light, temperature, moisture, continentality, soil reaction, and nutrients. EIVs were assigned to the species data and average values were calculated for each relevé in the JUICE. On average, EIVs could be assigned to 50% of the species of a relevé (minimum 18%, maximum 86%).

The species diversity of each relevé was determined according to the Shannon-Wiener index. Unconstrained ordination was used to find major gradients in species composition and describe the general pattern in species distribution along the gradients. The dataset was subjected to detrended correspondence analysis (DCA) using CANOCO 4.5 (Ter Braak & Smilauer 2002). The Monte Carlo permutation test (499 numbers of permutations under full model) was further applied in order to determine the statistical significance of measured environmental variables (altitude, inclination, PDIR and heat-load index) in explaining the species composition using "stepwise forward selection" of explanatory variables under CANOCO 4.5.

The species richness in five associations and sub-associations was estimated using sample-based rarefaction that allows suitable comparison of species richness estimated from samples in different sizes (Koellner et al. 2004, Chiarucci et al. 2009, Gotelli & Colwell 2011). The rarefaction curves were created using the 'vegan' package in the R program (Oksanen et al., 2015, R Development Core Team 2015). In order to evaluate the degree of floristic resemblance between the new associations in the study area and the plant associations previously identified by other researchers were compared using the Sørensen's Similarity Index (Sørensen 1948). It was calculated as [2C/ (A + B)] ×100, where (A) and (B) are the total species in the previously described association (A) and in the newly described association (B) respectively, while (C) is the number of species common to both associations. The threshold value is accepted as above 50% for floristic similarity. Characteristic species of higher units were taken from Akman et al. (1978a, b, c) and Quézel et al. (1978). The rules of the International Code of Phytosociological Nomenclature (Weber et al. 2000) were followed in naming the new syntaxa.

Results

The TWINSPAN classification revealed a drought gradient from left to right in the vegetation table (Table 3–6). On the first and second level of division, shoreline (6 relevés), and riparian vegetation (8 relevés), were clearly separated from forest-steppe vegetation. On the third level, forest-steppe vegetation (27 relevés) was separated from the steppe vegetation (28 relevés), except 3 relevés of forest-steppe vegetation, which were situated within steppe vegetation due to high similarity (56.4% similarity). Especially, *Quercus pubescens*-dominated forest had many common species with steppe vegetation due to its low tree cover (Figure 4 and 6). These relevés were included in forest-steppe vegetation. Only forest-steppe vegetation was divided into two sub-associations with a separate classification, whereas other vegetation types were not further divided since they had a homogenous floristic composition.

Description of vegetation units

Unit 1: *Phragmites australis* (Cav.) Trin. ex Steudel community in Table 3.

This community is dominated by *Phragmites australis* (Cav.) Trin. ex Steudel which generally occurs along shoreline, riparian areas, coasts, and marshes. In the study area, the community distribute along the shoreline of Narlıgöl in the north of study area between 1360 and 1372 m a.s.l. (Figure 2). *Polypogon monspeliensis* (L.) Desf., *Conyza canadensis* (L.) Cronquist, and *Carthamus glaucus* M. Bieb. subsp. *glaucus* are the other coexisting species in the *Phragmites* community. The community occurs on sandy clay loam, non-salty (0.0055%), neutral (pH: 7.34), and medium calcareous soils (14.86%; in Table 2). The organic matter (1.93%) and phosphorous (11.43 ppm) content of the soils are low, whereas nitrogen amount (0.1105%) is adequate.

Figure 2: *Phragmites australis* community in Narlıgöl.
Photo: Fatoş Şekerciler.
Slika 2: Združba z vrsto *Phragmites australis* pri jezeru Narlıgöl.
Foto: Fatoş Şekerciler.

Table 2: The soil characteristics of the vegetation types in the study area.
Tabela 2: Značilnosti tal vegetacijskih tipov na preučevanem območju.

Vegetation type	Sand (%)	Silt (%)	Clay (%)	NaCl (%)	EC (dS/m)	pH	Org. Matter (%)	P (ppm)	K (ppm)	CaCO3 (%)	N (%)
Steppe vegetation	52.6	9.9	37.6	0.0	0.4	6.7	1.0	5.1	173.6	1.5	0.1
	64.6	25.9	9.6	0.0	0.1	7.8	0.5	7.0	99.9	1.8	0.1
	54.6	21.9	23.6	0.0	0.2	6.9	1.7	6.0	100.0	1.5	0.1
	72.6	15.9	11.6	0.0	0.1	7.1	0.3	4.0	55.0	0.9	0.1
	54.6	17.9	27.6	0.0	0.2	6.9	1.6	7.0	113.7	1.9	0.1
Forest-steppe (typicum)	54.6	17.9	27.6	0.0	0.2	5.3	0.5	52.6	81.9	1.5	0.0
Forest-steppe (*quercetosum trojanae*)	40.6	5.9	53.6	0.0	0.5	7.0	1.9	6.4	211.2	7.3	0.1
	30.6	19.9	49.6	0.0	0.3	6.8	2.6	9.5	212.5	2.5	0.1
	32.6	15.9	51.6	0.0	0.5	7.0	1.9	7.9	191.1	0.9	0.1
Riparian vegetation	58.6	17.9	23.6	0.0	0.3	7.3	3.0	19.8	359.5	2.6	0.0
Lakeside vegetation	62.6	9.9	27.6	0.0	0.2	7.3	1.9	11.4	69.7	14.9	0.1

Table 3: *Phragmites australis* community.
Tabela 3: Združba z vrsto *Phragmites australis.*

	61	62	63	64	65	66
Twinspan division 1	1	1	1	1	1	1
Altitude (m)	1357	1369	1368	1368	1371	1372
Aspect	W	W	SW	S	SE	SE
Inclination (°)	5	5	5	5	5	5
Relevé size (m²)	25	25	25	25	25	25
Vegetation cover (%)	70	70	65	70	65	70
Phragmites australis	3	3	3	3	3	3
Polypogon monspeliensis	1	+	+	1	+	+
Conyza canadensis	+	1	+	+	+	+
Carthamus glaucus	1	+	+	+	+	.
Characteristic species of *Phragmition* communis						
Schoenoplectus lacustris subsp. *lacustris*	2	1	+	1	.	.

	61	62	63	64	65	66
Characteristic species of *Phragmito-Magnocaricetea* and *Phragmitetalia*						
Mentha longifolia subsp. *thyphoides*	1	+	+	+	.	+
Epilobium hirsutum	1	1	+	1	.	.
Companions	.	.	.	.	.	.
Bromus tectorum	+	+	+	+	+	+
Solanum luteum	2	2	1	2	.	.
Polypogon viridis	1	+	1	.	.	+
Centaurea solstitialis	1	+	1	1	.	.
Achillea cappadocica	+	+	+	+	.	.
Echinops ritro	.	.	1	1	1	1
Juncus heldreichianus subsp. *orientalis*	1	+	.	.	.	2
Asperula stricta subsp. *stricta*	.	1	.	.	1	1
Reseda lutea	+	.	.	.	+	+
Cynodon dactylon	.	+	.	.	+	+
Convolvulus arvensis	.	+	.	.	+	+
Juncus heldreichianus subsp. *orientalis*	1	+	.	.	.	2

Unit 2: *Pastinaco sativae-Populetum nigrae ass. nov. hoc loco*

Holotypus Relevé 52 in Table 4.

Characteristic species: *Populus nigra* L. subsp. *nigra*, *Pastinaca sativa* L. subsp. *urens, Elaeagnus angustifolia* L., *Mentha longifolia* (L.) Hudson subsp. *thyphoides* (Briq.) Harley, *Cirsium pubigerum* (Desf.) DC., *Juncus inflexus* L. subsp. *inflexus, Catabrosa aquatica* (L.) P. (Beauv.).

The association is dominated by *Populus nigra* L. which forms mixtures with *Populus alba* L., *Salix* spp. L., *Acer* spp. L., *Carpinus* spp. L., *Ulmus* spp. L., *Fraxinus* spp. L. in mixed riparian forests and with oaks in old forests. This association is found in riparian areas within Narköy village (Figure 3). The inclination varies between 30° and 45°, and the altitude ranges from 1388 m to 1447 m a.s.l.

Figure 3: *Pastinaco sativae-Populetum nigrae* association in Narköy village. Photo: Fatoş Şekerciler.

Slika 3: Asociacija *Pastinaco sativae-Populetum nigrae* pri jezeru v vasi Narköy. Foto: Fatoş Şekerciler.

Table 4 (Tabela 4): *Pastinaco sativae-Populetum albae.*

Relevé No	49	50	51	52*	53	54	55	56
Twinspan division 1	0	0	0	0	0	0	0	0
Twinspan division 2	1	1	1	1	1	1	1	1
Altitude (m)	1388	1444	1447	1428	1429	1424	1419	1416
Aspect	SW	W	NE	SW	SW	SSW	NE	SEE
Inclination (°)	45	45	30	40	40	40	40	30
Relevé size (m²)	25	25	25	25	25	25	25	25
Vegetation cover (%)	70	80	65	80	80	80	85	85
Characteristic species of the association								
Populus nigra subsp. *nigra*	3	4	3	2	3	3	3	3
Pastinaca sativa	2	.	.	1	1	1	2	2
Elaeagnus angustifolia	1	3	2	2	1	.	.	.
Mentha longifolia subsp. *thyphoides*	.	2	.	1	1	.	2	2
Cirsium pubigerum	.	.	.	1	.	1	1	.
Juncus inflexus	1	2	1	.	.	.	.	.
Catabrosa aquatica	2	.	.	.	.	.	.	2

Relevé No	49	50	51	52*	53	54	55	56
Characteristic species of *Alno glutinosae-Populetea albae, Populetalia albae, Populion albae*								
Salix alba	2	2	2	3	3	3	3	4
Urtica dioica	.	.	.	1	.	.	2	2
Vitis sylvestris	.	.	.	1	.	.	.	.
Calamagrostis pseudophragmites	.	1	1	.	.	.	.	.
Characteristic species of *Quercetea pubescentis*								
Crataegus monogyna var. *monogyna*	.	1	1	.	.	1	.	2
Characteristic species of *Molinio-Arrhenathereta* and *Arrhenatheretalia*								
Alopecurus arundinaceus	.	.	.	2	.	.	.	.
Dactylis glomerata	1	1	.	.	.	1	.	.
Epilobium hirsutum	.	.	.	1	1	.	1	1
Plantago major	.	.	.	2	.	.	.	.
Lotus corniculatus	.	.	1	.	.	.	.	.
Companions								
Rosa canina	1	.	1	1	1	1	2	2
Agrostis capillaris	.	1	1	2	.	.	2	1
Elymus hispidus subsp. *hispidus*	.	.	.	2	2	2	2	1
Sonchus asper subsp. *glaucens*	.	.	.	1	1	.	1	1
Medicago sativa subsp. *sativa*	2	1	3	.	3	.	.	.
Lolium rigidum var. *rigidum*	2	2	1	.	1	.	.	.
Pyrus communis subsp. *sativa*	3	2	.	.	.	2	.	.
Carthamus glaucus	1	1	.	1	.	.	.	.
Trifolium elongatum	.	.	.	.	1	3	1	.
Sanguisorba minor subsp. *balearica*	.	.	1	1	.	1	.	.
Cydonia oblonga	.	.	.	1	2	.	2	.
Ononis spinosa subsp. *leiosperma*	1	1	1	.	.	.	.	.
Ephedra major	1	1	.	.	.	.	.	.
Festuca valesiaca	.	.	2	.	.	1	.	.
Cota tinctoria	.	.	1	.	.	.	.	1
Eryngium campestre	1	.	1	.	.	.	.	.
Vicia cracca subsp. *cracca*	.	.	.	.	1	2	.	.
Colutea cilicica	.	.	.	1	.	.	1	.
Allium paniculatum subsp. *paniculatum*	.	.	.	1	.	.	.	.
Trifolium physodes subsp. *physodes*	.	.	.	1	.	.	.	.
Cotoneaster nummularius	.	.	1	.	.	.	.	.
Cirsium lappaceum subsp. *anatolicum*	.	.	.	.	.	.	.	1
Carex hirta	.	.	1	.	.	.	.	.
Tanacetum parthenium	.	.	.	1	.	.	.	.
Cerasus mahaleb	.	.	.	1	.	.	.	.
Berberis vulgaris	.	.	.	.	1	.	.	.
Viscum album	.	.	.	.	.	1	.	.

The association occurs on the south-western and north-eastern slopes. The vegetation cover varies between 65% and 85%. Soil of the association is rich in terms of phosphorus (19.80 ppm) and potassium content (359.51 ppm; in Table 2). However, it is mediocre and poor in terms of organic matter (3.04%) and nitrogen amount (0.0421%), respectively. The soils are also neutral (pH: 7.32).

Unit 3: *Cotoneastro nummulariae-Quercetum pubescentis ass. nov. hoc loco*

Holotypus, Relevé 58 in Table 5.

Characteristic species: *Quercus pubescens* Willd., *Phleum montanum* C. Kroch, *Juniperus oxycedrus* L. subsp. *oxycedrus, Cotoneaster nummularia* Fisch. and Mey

The dominant species of the association is *Quercus pubescens* which has a wide distribution ranging from the

Table 5 (Tabela 5): *Cotoneastro nummulariae-Quercetum pubescentis.*
Table 6 (Tabela 6): *Astragaletum plumoso-microcephalii.*

Relevé No	**1**	**2***	**3**	**4**	**5**	**6**	**7**	**8**	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**69**	**45**	**46**	**47**	**48**	**57**	**58***	**59**	**60**	**67**	**68**
Twinspan division 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Twinspan division 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Twinspan division 3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	1	1	1	1	1	1
Twinspan division 4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0
Altitude (m)	1737	1746	1759	1733	1739	1733	1745	1734	1710	1722	1711	1725	1734	1739	1742	1747	1717	1685	1674	1682	1668	1704	1708	1716	1739	1687	1718
Aspect	W	W	W	W	SW	SW	SW	SE	NW	N	E	NE	N	E	E	NE	NE	NE	NE	NE	SE	NW	NW	NW	NW	NN	NW
Inclination (°)	30	35	40	20	5	10	10	35	50	35	40	45	50	50	45	40	40	15	40	15	30	50	45	55	20	30	20
Vegetation cover (%)	75	90	95	70	85	80	90	90	80	80	80	85	95	85	95	95	80	85	95	85	85	85	75	90	80	70	70
Characteristic species of the association																											
Quercus pubescens	3	3	3	2	3	3	4	4	4	4	4	4	4	4	4	4	3	4	4	4	4	5	4	5	4	4	4
Cotoneaster nummularius	.	1	1	1	1	1	.	.	1	1	2	1	1	1	1	1	.	1	1	.	.	1	.	.	.	1	1
Juniperus oxycedrus subsp. *oxycedrus*	.	2	.	.	.	.	.	.	2	1	.	.	.	.	.	.	1	1	1	.	.	1	2	.	.	2	1
Phleum montanum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	1	2	.	.	.	1
Differential species of *quercetosum trojanae*																											
Quercus trojana	3	3	4	3	2	3	2	3	3	3	2	3	3	3	3	3	2	.	.	.	.	.	.	.	.	.	.
Dorycnium hirsutum	2	1	1	2	1	.	2	.	.	.	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Poa sterilis	2	2	2	2	2	2	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Prunus divaricata	1	1	1	.	1	1	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Filipendula vulgaris	2	1	1	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Scorzonera mollis subsp. *mollis*	.	1	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Characteristic species of *Quercion anatolicae* and *Querco-Carpinetalia orientalis*																											
Vicia cracca subsp. *cracca*	2	2	3	1	.	.	2	2	.	.	.	1	1	1	1	1	.	.	.	.	.	.	.	.	.	.	.
Securigera varia	2	2	1	2	2	2	2	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Clinopodium vulgare subsp. *arundanum*	.	.	2	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.
Lathrus digitatus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.
Characteristic species of *Quercetea pubescentis*																											
Teucrium chamaedrys subsp. *chamaedrys*	2	2	2	2	2	.	2	.	.	2	1	1	2	.	2	.	1	.	.	1	1	2	.	.	2	.	2
Trifolium elongatum	2	1	1	2	2	1	2	1	.	.	.	1	1	2	3	2	.	.	.	3	3	.	1	.	.	.	.
Trifolium physodes subsp. *physodes*	2	.	.	2	.	.	.	1	.	1	2	2	2	2	2	.	.	2	2	.	.	.	.	.	.	.	.
Characteristic species of *Onobrychido armenae-Thymetalia leucostomi*																											
Thymus sipyleus	2	3	.	1	1	1	1	1	1	2	2	3	2	3	1	1	1	2	.	.	.	2	1	1	.	1	1
Cota tinctoria	1	2	1	1	.	1	1	1	1	1	1	1	1	2	1	1	.	1	1	1	1	2	.	.	1	.	.
Galium verum	2	2	2	1	1	2	2	1	2	2	2	.	2	2	3	3	.	1	1	1	1	.	.	.	.	.	.
Astragalus microcephalus	.	.	.	.	2	.	.	.	.	2	2	3	1	2	3	2	2	2	2	2	2	.	.	2	2	1	2

Centaurea virgata	.	.	.	2	2	2	1	1	.	2	1	1	1	1	1	1	1	1	1	.	.	.	.	.	.	1	.
Dianthus crinitus var. crinitus	.	.	.	.	.	.	.	.	1	1	1	1	1	.	.	1	.	1	1	2	2	.	.	.	1	.	.
Scabiosa argentea	1	.	.	1	.	1	1	.	.	.	.	.	.	.	.	.	.	2	1	.	.	1	1	1	.	1	1
Taeniatherum caput-medusae subsp. *crinitum*	.	.	.	.	.	2	2	.	1	.	.	.	1	1	1	.	1	.	.	1	1	.	.	.	.	.	.
Stachys cretica	.	2	2	1	.	1	1	.	.	.	.	1	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.
Inula montbretiana	1	.	.	1	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Phlomis pungens var. *hirta*	.	.	.	.	2	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Salvia absconditiflora	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Characteristic species of *Astragalo-Brometea*																											
Festuca valesiaca	2	3	3	3	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3	2	2	3	2	2	3	3	2
Minuartia juniperina	.	2	.	1	2	2	2	1	.	1	3	3	3	3	2	2	1	.	.	.	.	2	.	1	.	.	2
Alyssum murale subsp. *murale*	.	1	.	2	.	.	1	1	.	.	.	.	1	1	2	1	.	.	.	.	.	.	.	.	.	.	.
Potentilla recta	1	1	1	1	.	1	1	1	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.
Veronica thymoides subsp. *hasandaghensis*	.	2	2	.	.	.	.	.	.	2	2	.	.	1	1	2	.	.	.	.	.	.	.	.	.	.	.
Eryngium campestre	1	.	.	.	1	.	.	.	.	.	1	.	.	.	.	.	.	1	1	.	2	.	.	.	.	.	.
Helichrysum plicatum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	2	.	2	.	2	1	1
Bromus tomentellus	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	3	3	.	.	.	.	.	.
Teucrium polium	.	.	.	.	.	2	.	2	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.	2	1
Stipa holosericea	.	.	.	.	.	2	.	.	.	.	.	.	1	1	1	.	.	.	.	.	.	.	.	.	.	.	.
Daphne oleoides subsp. *oleoides*	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	1	1
Leontodon asperrimus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.
Bromus tectorum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.
Morina persica	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.
Astragalus angustifolius	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Companions																											
Allium paniculatum subsp. *paniculatum*	1	1	.	1	.	1	1	1	1	1	1	1	.	.	.	.	.	.	.	.	.	1	.	1	1	.	.
Sanguisorba minor subsp. *balearica*	.	1	1	2	1	.	1	.	1	2	1	1	1	1	2	2	.	.	.	.	.	.	.	.	.	.	.
Dactylis glomerata	1	1	1	1	1	1	.	1	1	.	1	1	1	2	1	1	1	1	1	1	1	1	1	1	.	1	.
Bromus japonicus subsp. *anatolicus*	2	.	2	2	2	1	2	2	1	2	1	.	1	2	2	2	2	.	2	2	2	.	2	2	.	2	.
Globularia trichosantha	2	.	1	2	1	1	1	1	1	1	3	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	2
Astragalus plumosus var. *akardaghicus*	.	1	.	1	2	2	.	2	3	2	2	2	1	.	.	.	.	.	.	.	.	.	2	.	.	1	.
Xeranthemum annuum	.	.	.	1	.	1	2	1	2	.	1	.	.	1	1	.	1	.	.	1	1	.	.	.	.	.	1
Phleum exaratum	2	1	1	2	.	1	1	1	1	1	.	.	.	.	.	1	.	1	.	.	.	.	.	.	.	.	.
Pilosella piloselloides	.	.	.	.	.	.	.	.	.	.	.	1	1	1	1	1	.	1	2	3	3	.	.	.	1	.	.
Elymus hispidus subsp. *hispidus*	3	.	1	2	1	.	1	1	.	.	.	.	.	.	.	.	.	1	.	2	2	.	2	.	.	.	.
Rosa canina	.	.	.	.	.	.	.	.	1	1	.	.	.	.	.	.	.	2	2	1	1	1	.	1	1	.	.
Poa pratensis	.	.	.	.	.	.	.	.	2	.	1	.	1	1	.	.	.	.	.	.	.	2	2	1	1	.	1
Hordeum bulbosum	1	1	.	1	.	.	1	.	.	.	.	1	.	1	.	.	.	1	1	.	.	.	.	.	.	.	.

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Relevé No	1	2*	3	4	5	6	7	8	28	29	30	31	32	33	34	35	69	45	46	47	48	57	58*	59	60	67	68
Rostraria cristata	.	2	.	.	.	.	.	.	1	2	1	.	1	.	.	.	1	.	3	.	.	.	.	.	.	.	2
Apera intermedia	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	1	1	.	2	2	1	1	2
Picnomon acarna	.	.	.	.	.	.	.	.	.	1	.	.	.	2	.	.	.	1	.	2	2	3	.	.	.	1	.
Scutellaria salviifolia	.	.	.	.	.	.	.	2	.	2	1	1	.	.	1	1	.	.	.	.	.	.	.	.	.	.	.
Pilosella cymosa	2	2	2	.	2	1	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Campanula stricta var. *stricta*	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	3	.	.	.	1	1	.	.	1	.
Fumana aciphylla	.	.	.	.	.	2	.	.	2	1	.	.	2	.	.	2	.	.	.	.	.	.	.	.	.	.	.
Pilosella hoppeana subsp. *testimonialis*	.	.	.	.	.	.	.	.	.	2	.	.	1	.	.	.	.	.	2	2	2	.	.	.	.	.	.
Elymus hispidus subsp. *podpyerae*	.	.	.	.	.	.	1	1	.	.	.	.	.	.	.	.	.	2	2	.	.	.	.	.	.	.	.
Lotus corniculatus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	1	1	.	.	.	.	.	.
Onobrychis sulphurea	1	.	1	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Carex divisa	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	2	.	.
Carum meifolium	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	1	.	.
Dianthus zonatus var. *zonatus*	.	.	.	1	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.
Helianthemum canum	.	.	.	.	.	.	.	.	1	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Elymus hispidus subsp. *barbellatus*	.	.	.	.	.	.	.	.	.	.	.	.	2	2	.	.	.	.	.	.	.	.	.	.	2	.	.
Asperula stricta subsp. *stricta*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	1	.	.	.
Carthamus glaucus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.	.	.	.
Crataegus szovitsii	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.	.	.	.	.	.
Achillea lycaonica	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	2	2	.	.	.	.	.	.
Crataegus monogyna var. *monogyna*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	2	.	.	.

Other species with less frequencies: *Atriplex davisii* (R47, +1), *Lathyrus aureus* (R60, 13), *Berberis vulgaris* (R67, 11), *Linaria genistifolia* subsp. *polyclada* (R46, +1), *Rhamnus hirellus* (R1, +1), *Cuscuta balansae* (R29, +1), *Trifolium stellatum* (28, +2), *Thymelea passerina* (R69, +1), *Stachys iberica* (R33, +1), *Cydonia oblonga* (R8, 11), *Melica ciliata* (R7, +1), *Ononis pusilla* (R6, +1), *Acantholimon ulicinum* (R6, +2), *Epipactis helleborine* (R4, +1), *Bunium microcarpum* subsp. *microcarpum* (R3, +1), *Prunella orientalis* (R2, +1), *Trifolium campestre* (R47, +2), *Salvia tomentosa* (R1, 12), *Elymus panormitanus* (R69, 12), *Orobanche anatolica* (R1, +1), *Dianthus micranthus* (R34, R35, +1), *Achillea setacea*, *Ononis spinosa* subsp. *leiosperma, Verbascum lasianthum* (R 45, R46, +1), *Ziziphora clinopodioides* (R33, R69, +1), *Cirsium lappaceum* subsp. *anatolicum* (R5, R8, +1), *Scariola orientalis* (R30, R34, +1), *Rumex acetosella* (R31, R59, +1), *Rumex tuberosus* subsp. *tuberosus* (R2, R7, +1), *Juniperus excelsa* (R68, 22; R69, 11), *Medicago sativa* subsp. *sativa* (R1, +3, ; R45, +1), *Dianthus calocephalus* (R1, R6, +2).

West, Central, and South Europe to Crimea and Anatolia due to drought tolerance (Davis 1965–1985). It could cope with both moderate summer drought stress and low winter temperatures (Pasta et al. 2016). *Q. pubescens* coexists with *Phleum montanum, Juniperus oxycedrus* subsp. *oxycedrus,* and *Cotoneaster nummularia* in the study area. They are native species in the woodlands and grasslands of the Mediterranean and Irano-Turanian regions and their altitudinal range varies from sea level to 2200m a.s.l. (Davis 1965–1985). The vegetation cover is high and varyies from 70% to 95%. The altitudinal range of the association is between 1400 m and 1750 m a.s.l., and the inclination varies between 5° and 55°. The association usually distributes in north-eastern, north-western, western, and south-western slopes between Bozköy and Kayırlı villages, around Narköy village and the upland of Divarlı (Figure 4).

Two sub-associations of *Cotoneastro nummulariae-Quercetum pubescentis* are described in the study area.

Figure 4: *Cotoneastro nummulariae-Quercetum pubescentis* between Güzelyurt and Bozköy. Photo: Nihal Kenar.

Slika 4: *Cotoneastro nummulariae-Quercetum pubescentis* med mestoma Güzelyurt in Bozköy. Foto: Nihal Kenar.

Unit 3.1: *quercetosum trojanae* subass. nov. hoc loco

Holotypus Relevé 2 in Table 5.

Differential species: *Quercus trojana* P.B. Webb subsp. *trojana, Dorycnium hirsutum* (L.) Ser., *Poa sterilis* Bieb., *Prunus divaricata* Ledeb., *Filipendula vulgaris* Moench, *Scorzonera mollis* Bieb. subsp. *mollis.*

Quercus trojana subsp. *trojana,* an East Mediterranean element, coexists with other deciduous *Quercus* species and *Pinus brutia* Ten. in the northwest, west, and southwest of Anatolia between 300 m and 1800 m a.s.l. Differential species of *quercetosum trojanae* are *Dorycnium hirsutum*, *Poa sterilis*, *Prunus divaricata*, *Filipendula vulgaris, Scorzonera mollis* subsp. *mollis.* The sub-association is found in Divarlı upland and western, south-western, and north-western slopes where the inclination varies between 5° and 50°. The altitudinal range is between 1700 m and 1760 m a.s.l. The vegetation cover ranged between 70% and 95%.

Unit 3.2: *typicum* subass. nov. hoc loco

Holotypus is the same as for the name of the association, Relevé 58 in Table 5.

Differential species: *Phleum montanum* C. Kroch, *Juniperus oxycedrus* L. subsp. *oxycedrus*

The vegetation cover of the sub-association varies between 70% and 95%. It occurs on slopes whose inclination is between 15° and 55°. It is mostly found on the north-eastern and north-western slopes of Narköy upland and between Bozköy and Kayırlı villages at an altitude of about 1410 m and 1720 m a.s.l.

Unit 4: *Astragaletum plumoso-microcephalii ass. nov. hoc loco*

Holotypus Relevé 38 in Table 6.

Characteristic species: *Astragalus microcephalus* Willd. subsp. *microcephalus, Astragalus plumosus* Willd.*, Allium paniculatum* L. subsp. *paniculatum*

The dominant species of the association was *Astragalus microcephalus* subsp. *microcephalus,* which is widespread and a Irano-Turanian chamaephyte. *A. microcephalus* could occur up to 2700 m, whilst *A. plumosus* and *Allium paniculatum* subsp. *paniculatum* is found only up to 2000 m. The association distributes in Güzelyurt-Sivrihisar, Bozköy-Kayırlı, and Akyamaç villages, Kızılkilise, and Divarlı upland. It occurs on northern, north-western, and north-eastern slopes between 1650 m and 1800 m a.s.l. (Figure 5). The mean cover of the association varies between 75% and 95% between the inclinations from 5° to 60°. The soils are non-saline (0.0037%–0.0123%) and calcareous (0.87%–1.75%; in Table 2). The soil texture was described as sandy clay and sandy loam. The amount of organic matter is low and between 0.31% and 1.65% in the soil. The amount of nitrogen, phosphorous, and potassium is between 0.0526% and 0.01158%, 3.96 and 7.04 ppm, and 54.98 and 113.71 ppm in the soil, respectively.

Figure 5: *Astragaletum plumoso-microcephalii* in upland of Divarlı village. Photo: Nihal Kenar.

Slika 5: *Astragaletum plumoso-microcephalii* na gorovju pri vasi Divarlı. Foto: Nihal Kenar.

Table 6 (Tabela 6): *Astragaletum plumoso-microcephalii.*

Relevé No	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	36	37	38*	39	40	41	42	43	44
Twinspan division 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Twinspan division 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Twinspan division 3																												
Altitude (m)	1789	1784	1803	1795	1661	1672	1682	1674	1734	1736	1777	1786	1779	1752	1756	1723	1720	1711	1693	1748	1758	1786	1797	1773	1800	1806	1811	1785
Aspect	E	SE	W	NW	W	SW	SW	NW	S	S	SW	E	NW	NE	NE	NE	N	W	N	NE	NW	NW	W	SE	NE	N	NE	N
Inclination (°)	5	10	40	50	45	60	50	60	45	45	40	25	50	30	45	40	45	50	30	40	45	5	20	35	10	25	15	25
Relevé size (m²)	64	64	64	64	64	64	64	64	64	64	64	64	64	64	64	64	64	64	64	64	64	64	64	64	64	64	64	64
Vegetation cover (%)	85	75	85	85	80	85	90	95	45	90	80	75	85	90	60	95	85	95	85	80	90	85	80	70	75	80	75	80
Characteristic species of the association																												
Astragalus microcephalus	4	4	4	4	4	4	4	5	3	4	3	3	4	4	3	5	4	5	3	3	5	3	3	3	2	2	3	3
Astragalus plumosus	1	.	.	2	.	.	.	.	.	.	.	1	.	1	2	.	.	.	2	1	.	2	1	.	3	.	.	.
Allium paniculatum subsp. *paniculatum*	.	.	.	.	.	.	.	.	.	1	1	.	.	.	1	.	.	.	.	.	.	1	.	1	.	1	.	.
Characteristic species of *Phlomido armeniaceae-Astragalion microcephalii*																												
Dianthus zonatus var. *zonatus*	.	2	.	.	1	.	.	.	.	.	.	.	.	1	.	.	2	.	.	1	.	.	.	.	.	.	.	.
Potentilla recta	1	.	.	.	.	.	.	.	1	.	.	.	.	.	1	.	.	.	.	2	.	1	.	.	.	.	.	.
Characteristic species of *Onobrychido armenae-Thymetalia leucostomi*																												
Thymus sipyleus	2	2	2	2	2	2	2	2	1	2	2	.	2	1	1	1	.	.	.	2	.	2	.	1	1	1	1	3
Centaurea virgata	.	.	.	1	1	.	1	3	1	1	2	2	2	1	1	.	2	2	1	1	.	1	1	1	1	.	1	.
Phlomis armeniaca	2	1	.	.	.	.	2	.	1	1	1	1	1	.	.	.	.	.	.	1	2	1	1	1	3	2	1	.
Scabiosa argentea	.	.	1	1	1	1	2	1	.	.	.	.	.	.	.	.	2	2	1	.	1	.	.	1	1	.	.	.
Teucrium chamaedrys subsp. *chamaedrys*	.	.	.	.	.	.	.	.	2	1	.	3	3	2	2	.	.	.	2	3	.	.	.	.	.	3	2	2
Euphorbia macroclada	.	.	2	2	1	1	.	3	.	.	.	.	.	.	.	.	1	1	.	1	.	.	.	.	.	.	.	.
Cota tinctoria	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	1	3	2	.	.	.	.	.	.	1	.	.	.
Galium verum	.	.	.	.	.	.	.	.	2	2	.	.	2	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.
Dianthus crinitus var. *crinitus*	1	.	.	.	.	.	.	2	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.	1	.	.	.
Teucrium polium	.	.	.	.	.	.	.	.	.	.	.	3	.	.	.	1	.	.	.	.	.	.	.	2	.	3	.	.
Asyneuma limonifolium subsp. *pestallozzea*	1	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Phlomis pungens var. *hirta*	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	2	.	.	.	.	.	.	.	.
Stachys cretica	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.
Characteristic species of *Astragalo-Brometalia*																												
Sanguisorba minor subsp. *balearica*	2	.	1	.	1	.	.	.	.	.	.	.	.	.	2	2	.	.	.	.	.	.	.	.	2	.	.	.
Globularia trichosantha	.	.	.	.	.	.	.	.	1	1	1	.	.	.	1	.	.	.	.	1	.	.	.	.	.	.	3	.
Characteristic species of *Astragalo-Brometea*																												
Festuca valesiaca	3	2	3	3	.	.	.	.	2	2	3	3	3	3	3	2	2	2	3	3	2	3	2	2	3	4	3	2
Taeniatherum caput-medusae subsp. *crinitum*	2	2	2	2	.	3	3	.	3	2	2	1	.	.	1	.	.	2	.	1	1	.	2	2	2	.	.	.

Eryngium campestre	1	.	1	.	.	.	.	.	1	1	.	1	2	1	1	.	2	.	2	1	.	1	1	1	.	.	1	1
Minuartia juniperina	.	2	.	.	.	.	.	.	2	1	3	2	3	.	3	1	.	.	1	2	.	2	3	1	1	.	3	.
Bromus tomentellus	.	.	.	.	.	.	.	2	.	1	1	.	1	.	1	1	.	.	.	1	.	.	2	.	.	.	1	1
Leontodon asperrimus	1	.	1	1	1	.	1	1	.	.	.	1	1	.	1	.	.	.	.	.	.	.	.	.	.	.	.	1
Bromus tectorum	.	.	.	2	1	1	.	2	.	.	1	3	.	.	.	.	.	2	.	.	2	.	.	.	.	.	.	.
Alyssum murale subsp. *murale*	.	1	1	.	.	2	.	1	.	1	.	.	.	.	1	1	.	.	.	.	1	.	.	.	.	.	.	.
Apera intermedia	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	2	2	.	2	2	.	2
Cruciata taurica	.	.	.	.	.	2	.	3	.	2	.	.	.	.	.	.	2	2	.	.	.	.	.	.	.	.	.	.
Anthemis cretica subsp. *albida*	.	.	.	.	.	.	.	3	1	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Inula montbretiana	2	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Morina persica	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Characteristic species of *Querco-Carpinetalia orientalis, Quercion anatolicae, Querco-Cedretalia libani, Quercetea pubescentis*																												
Trifolium physodes subsp. *physodes*	.	.	.	.	.	.	.	.	2	1	2	3	3	2	2	.	.	.	2	.	.	1	.	.	2	.	.	.
Cotoneaster nummularius	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.
Securigera varia	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Companions																												
Bromus japonicus subsp. *anatolicus*	2	2	2	2	2	2	2	2	.	2	1	1	3	.	1	.	2	2	2	2	.	1	2	1	2	1	2	2
Rostraria cristata	.	.	.	.	1	3	.	1	1	2	2	1	3	.	1	1	.	.	.	2	1	1	3	2	1	.	.	.
Dactylis glomerata	1	.	.	.	.	.	.	1	1	1	.	.	.	1	1	2	1	1	1	1	1	.	.	.	.	.	.	.
Xeranthemum annuum	1	1	1	1	.	2	2	2	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	2	.	.	1
Carthamus glaucus	1	.	1	.	.	.	.	.	.	.	.	.	.	1	.	1	1	1	1	.	1	3	1	.	.	.	1	.
Picnomon acarna	.	.	.	1	.	.	.	.	.	.	.	.	1	.	1	1	2	.	1	.	2	1	2	.	2	.	.	.
Elymus hispidus subsp. *hispidus*	.	.	.	.	.	.	.	.	.	.	.	1	1	1	.	.	2	2	.	.	.	.	.	.	.	2	2	1
Veronica thymoides subsp. *hasandaghensis*	.	.	2	.	.	.	.	.	1	.	.	1	.	.	2	.	2	.	1	.	.	.	1	.	.	.	1	.
Centaurea solstitialis	.	.	.	.	.	1	.	.	1	.	.	1	.	.	.	.	.	1	.	.	.	.	.	.	.	1	.	1
Scariola orientalis	.	.	.	1	1	2	1	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	1
Filago arvensis	.	.	1	.	.	.	2	.	.	1	.	.	.	.	.	.	.	.	.	.	1	.	1	.	.	.	.	1
Hordeum bulbosum	.	.	.	.	.	.	.	.	.	.	1	.	.	1	.	1	.	1	.	.	.	.	.	.	.	.	1	.
Phleum exaratum	.	.	.	.	.	2	2	.	1	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.	.	.	.	.
Trifolium campestre	.	.	.	.	.	.	.	.	.	2	1	2	2	.	.	.	.	.	.	.	.	.	.	.	3	.	.	.
Acantholimon ulicinum	.	2	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	2	.	2
Crataegus szovitsii	1	.	1	1	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.
Marrubium globosum subsp. *globosum*	.	.	.	2	3	2	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Helichrysum plicatum	.	.	.	.	.	.	.	.	2	2	.	2	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.
Stipa holosericea	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	1	.	.	1	.	3	.
Trifolium stellatum	.	.	.	.	.	.	.	.	.	.	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	2	2
Ziziphora clinopodioides	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	1	1	.	.	.	.
Onobrychis sulphurea	1	.	.	.	1	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Relevé No	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	36	37	38*	39	40	41	42	43	44
Carum meifolium	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	2	.	.	2	.
Achillea lycaonica	.	.	.	.	.	.	.	.	.	.	.	2	.	.	1	.	.	.	.	.	.	.	.	.	.	.	2	.
Scutellaria salviifolia	.	.	.	.	.	.	.	1	.	1	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Lotus corniculatus	.	.	1	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	1	.	.	.	.	.	.	.	.	.
Plantago lanceolata	.	.	.	.	.	.	.	.	.	.	1	1	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.
Elymus hispidus subsp. *barbellatus*	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	1	.	1	.	.	.	.	.	.
Rosa canina	.	.	.	1	.	.	.	1	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.
Dianthus micranthus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	2	3

Other species with less frequencies: *Alkanna orientalis* (R42, +3), *Rhamnus hirellus* (R36, +2), Ononis spinosa subsp. leiosperma (R25, +1), Nigella arvensis var. glauca, R26, +1*)*, *Pilosella hoppeana* subsp. *testimonialis* (R27, 12), *Poa pratensis* (R44, +1), *Cichorium intybus* (R20, +2), *Centaurea urvellei* subsp. *stepposa* (R18, +1), *Verbascum lasianthum* (R15, +1), *Senecio vernalis* (R14, +1), *Euphorbia falcata* subsp. *falcata* var. *galilaea* (R13, +2), *Euphrasia pectinata* (R11, 12), *Stachys iberica* (R9, +1), *Fumana aciophylla* (R40, +2), *Rumex acetosella* (R15, +1), *Pilosella piloselloides* (R27, +1), *Asperula stricta* subsp. *stricta* (R9, +1), *Orobanche anatolica* (R13, R16, +1*), Anchusa leptophylla* subsp. *incana* (R16 +1; R19 +2), *Alyssum minutum* (R36, R39, +1), *Helianthemum canum* (R36, R43, +2*), Campanula stricta* var. *stricta* (R21, +1; R27, +2), *Carduus nutans* (R15, R40, +1), *Scleranthus annuus* (R15, R25 +2), *Thymelea passerina* (R9, R15 +1), *Anchusa lept ophylla* subsp. *incana* (R16, +1; R19, +2).

Ordination analysis

Classification groups were well separated in the ordination diagram (DCA) except subassociations of *Cotoneastro nummulariae-Quercetum pubescentis* due to high floristical similarities. However, these sub-associations differ in terms of both dominant species and differential species. Azonal communities (*Phragmites australis* community and *Pastinaco sativae-Populetum nigrae*), which occurred on the lowest parts of the study area, were associated with moisture and nutrient indicator values (Figure 6). Forest (*Cotoneastro nummulariae-Quercetum pubescentis typicum* subass. and *Cotoneastero nummulariae-Quercetum pubescentis-quercetosum trojanae* subass.) and steppe communities (*Astragaletum plumoso-microcephalii*), which occurred on the highest altitudes, were associated with continentality indicator values. Higher temperature indicator value and endemism ratio were observed in the forest community (*Cotoneastero nummulariae-Quercetum pubescentis*), whereas light indicator value was higher in the steppe community (*Astragaletum plumoso-microcephalii).* Among measured environmental variables, altitude (F = 13.08, P = 0.002) and inclination (F = 2.77, P = 0.04) had a significant effect on the variation of species composition, while radiation (F = 1.95, P = 0.13) and heat-load (F = 0.51, P = 0.7) indices had non-significant effects.

Main vegetation types of the study area (steppe, forest-steppe, riparian, and shoreline) showed variations according to altitude and inclination (Figure 7). While *Phragmites australis* community had the lowest species diversity, *Cotoneastero nummulariae- Cotoneastro nummulariae-Quercetum pubescentis typicum* and *Quercetum pubescentis-quersetosum trojanae* had the highest species diversity in the study area (Figure 8). This was followed by *Astragaletum plumoso-microcephalii* occuring on slopes with the high inclination (Figure 7). A total of 12 endemic taxa were determined in the study area of which 11 were classified as LC (least concern) and one as NT (Near threatened) according to IUCN red list categories (Ekim et al. 2000). The endemism rate of the study area was 7.83%. The majority of the endemics were from Irano-Turanian region (5.42%). The highest number of endemic species was found in *Astragaletum plumoso-microcephalii* followed by *Cotoneastero nummulariae-Quercetum pubescentis quercetosum trojanae. Linaria genistifolia* subsp. *polyclada* (NT category), was represented in one relevé of *Cotoneastero nummulariae-Quercetum pubescentis.*

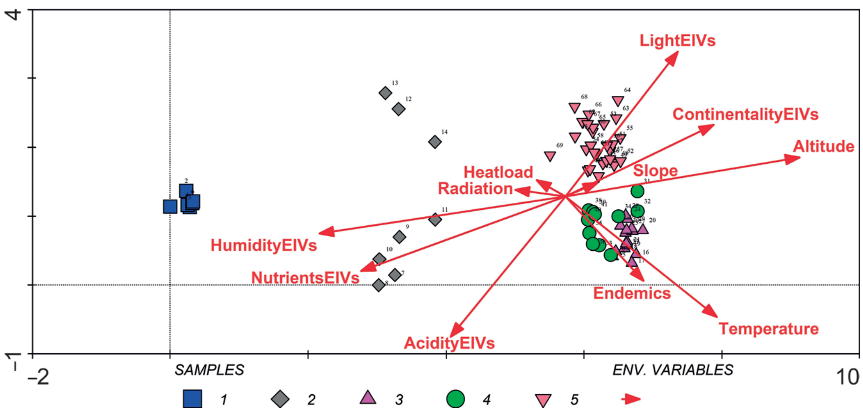
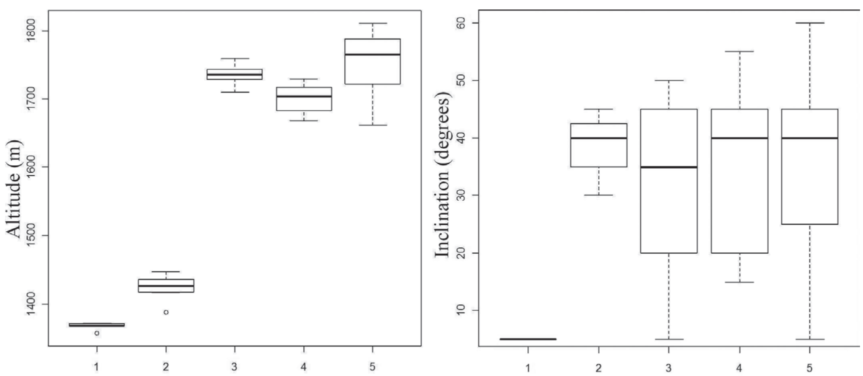


Figure 6: DCA analysis of plant communities in the study area (1. *Phragmites australis,* 2. *Pastinaco sativae-Populetum nigrae,* 3. *Cotoneastro nummulariae-Quercetum pubescentis quercetosum trojanae,* 4. *Cotoneastro nummulariae-Quercetum pubescentis typicum,* 5. *Astragaletum plumoso-microcephalii*).

Slika 6: Analiza DCA rastlinskih združb preučevanega območja (1. *Phragmites australis,* 2. *Pastinaco sativae-Populetum nigrae,* 3. *Cotoneastro nummulariae-Quercetum pubescentis quercetosum trojanae,* 4. *Cotoneastro nummulariae-Quercetum pubescentis typicum,* 5. *Astragaletum plumoso-microcephalii*).



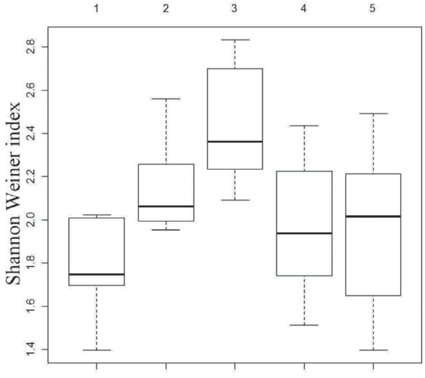


Figure 7: Variation of plant communities in the study area according to altitude, inclination and, species diversity (1: *Phragmites australis,* 2: *Pastinaco sativae-Populetum nigrae,* 3: *Cotoneastro nummulariae-Quercetum pubescentis quercetosum trojanae,* 4: *Cotoneastro nummulariae-Quercetum pubescentis* typicum, 5: *Astragaletum plumoso-microcephalii*).

Slika 7: Raznolikost rastlinskih združb preučevanega območja glede na nadmorsko višino, naklon in vrstno pestrost (1: *Phragmites australis,* 2: *Pastinaco sativae-Populetum nigrae,* 3: *Cotoneastro nummulariae-Quercetum pubescentis quercetosum trojanae,* 4: *Cotoneastro nummulariae-Quercetum pubescentis* typicum, 5: *Astragaletum plumoso-microcephalii*).

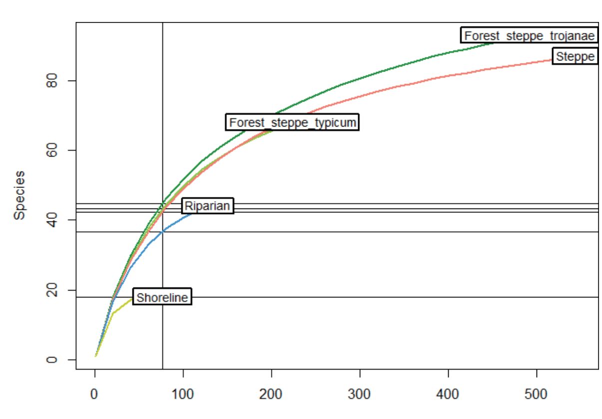


Figure 8: The sample-based rarefaction curve for species richness of the forest-steppe, steppe, riparian, and shoreline vegetation in the study area

Slika 8: Krivulja kopičenja vrst za gozdno stepo, stepo, obrečno in obalno vegetacijo, nastala na osnovi vzorčenj.

Life forms and Chorology

The ratio of Irano-Turanian elements (20%) was higher in *Cotoneastro nummulariae-Quercetum pubescentis* followed by an equal rate of Euro-Sibirian (11%) and Mediterranean elements (11%). However, the ratio of Mediterranean elements (28%) was equal to the Irano-Turanian (28%) in *Astragaletum plumoso-microcephalii.* On the other hand, *Pastinaco sativae-Populetum nigrae* was dominated by Euro-Siberian elements (18%) followed by Irano-Turanian elements (5%). In *Phragmites australis* community, Irano-Turanian (9%) and Euro-Sibirian (8) elements were almost in the same rate.

According to life forms spectrum, therophytes (45%) were higher in *Phragmites australis* community followed by cryptophytes (30%). Rate of phanerophytes (36%) were close to hemicryptophytes (35%) in *Pastinaco sativae-Populetum nigrae*. *Astragaletum plumoso-microcephalii* was rich in terms of hemicryptophytes (43%) and chamaphyte (26%). The ratio of hemicryptophytes (45%) was higher than chamaephytes (23%) and phanerophytes (14%) in *Cotoneastero nummulariae-Quercetum pubescentis*.

Discussion

Syntaxonomy

The general distribution of *A. microcephalus* was only reported in Caucasus and Iran in addition to Anatolia (Davis 1965–1985). The steppes dominated by *A. microcephalus,* which are in the oro-Mediterranean zone of the inner, southern, and eastern Anatolia, were classified under the class *Astragalo-Brometea* Quézel 1973. However, its borders around eastern Anatolia and Iran cannot be completely enlightened yet (Hamzaoğlu 2006; Noroozi et al. 2010). *Astragaletum plumoso-microcephalii,* which was determined as a new association, classified under the class *Astragalo-Brometea* and the order *Onobrychido armeni-Thymetalia leucostomi* comprising the steppe communities of Central Anatolian highlands. It occurs on non-saline, volcanic bedrock, and calcareous soils on steep slopes between 1650 m and 1800 m a.s.l. In the study area, *A. microcephalus* co-occurs with the characteristic species such as *Astragalus plumosus* and *Allium paniculatum* subsp. *paniculatum.* In addition, the species such as *Thymus sipyleus, Festuca valesiaca* and *Taeniatherum caput-medusae* subsp. *crinitum,* which are characteristics of *Phlomido armeniacae-Astragalion microcephalii* and *Astragalo microcephali-Brometea tomentelli,* were represented with a high cover values in the association. The *Astragalus microcephalus* associations in Anatolia, which have frequently dissimilar floristic composition, differ from each other in terms of ecological conditions such as soil, altitude, and slope (Hamzaoğlu et al. 2004; Hamzaoğlu 2005). For this reason, various *Astragalus microcephalus* associations were determined in Turkey (Hamzaoğlu 2005). When species composition of *Astragaletum plumoso-microcephalii* was compared with other *A. microcephalus* associations described in Anatolia, the highest similarities were found with *Salvio wiedemanni-Astragaletum microcephali* (35.8%) and *Centaureo deflexae-Astragaletum microcephali* (31.34%), respectively (Aydoğdu et al. 1994; Hamzaoğlu 2005). Although the dominant species of the associations is *A. microcephalus*, their characteristic species are quite different from each other. While *Salvio wiedemanni-Astragaletum microcephali* are described by the characteristics such as *Salvia wiedemannii* Boiss., *Bunium microcarpum* (Boiss.) Freyn subsp. *bourgaei* (Boiss.) Hedge & Lamand, *Thesium billardieri* Boiss., *Crucianella disticha* Boiss., and *Petrorhagia cretica* (L.) Ball & Heywood., *Centaureo deflexae-Astragaletum microcephali* are described with *Centaurea deflexa* Wagenitz and *Verbascum cheiranthifolium* Boiss. They are also classified in different alliances in the same order (*Onobrychido armeni-Thymetalia leucostomi*); while the former was included in *Astragalo karamasici-Gypsophilion eriocalycis* Ketenoğlu et al. 1983, the latter in *Arenario ledebouriani – Astragalion plumose* Akman 1990. In addition, they occur on different ecological conditions besides the floristic dissimilarity. The new association also has different site conditions (altitudinal range, soil, and main rock) compared to previously described ones. The former associations cannot rise up to 1100 m a.s.l., while *Astragaletum plumoso-microcephalii* occurs in the sub-alpine zone. The *Centaureo deflexae-Astragaletum microcephali* grows on gypsiferous soils and *Salvio wiedemanni-Astragaletum microcephali* also occurs on brown non-calcareous soils on granite main rock.

Thermophilous oak and conifer woodlands of semi-dry regions in Southern and Eastern Europe and Anatolia belong to the class *Quercetea pubescentis* (Oberd. 1948, Doing- Kraft 1955) Scamoni & Passarge 1959. In Turkey, Central Anatolian forest-steppe communities were classified under the alliance *Quercion anatolicae* Akman, Barbéro, & Quézel 1979 and the order *Querco cerridis-Carpinetalia orientalis* Quézel, Barbéro, & Akman 1980 of the above-mentioned class. *Cotoneastro nummulariae-Quercetum pubescentis*, which was firstly described in the study area, was classified under *Quercion anatolicae, Querco cerridis-Carpinetalia orientalis,* and *Quercetea pubescentis.* The species such as *Securigera varia, Vicia cracca* subsp. *stenophylla, Trifolium elongatum, Clinopodium vulgare subsp. arundanum,* and *Lathrus digitatus,* which are the characteristic species of the *Quercion anatolicae* and *Querco cerridis-Carpinetalia orientalis,* were frequently found as the understory of xeric oak forests in Central Anatolia. When we compare the xeric oak dominated forest-steppe associations in Central Anatolia in terms of floristic similarity, the new association was the most similar to the *Rhamno oleoidis-Quercetum pubescentis* (34.84%) association described in the Melendiz Mountain in the southeast of Central Anatolia which is found in a similar altitudinal range. The second similar association (30.82%) was *Trifolio-Quercetum pubescentis* which occurs in Soğuksu National Park in the northwest of Central Anatolia up to 1380 m a.s.l. (Adıgüzel & Vural 1995; Kenar & Ketenoğlu 2016). *Trifolio-Quercetum pubescentis* was described with the characteristic species such as *Vicia cracca* subsp. *stenophylla* Vel., *Lotus Aegeus* (Griseb.) Boiss., *Teucrium chamaedrys subsp. syspirense* (K. Koch), *Trifolium elongatum* Willd., *Muscari aucheri* (Boiss.) Baker, *Prunus divaricata* Ledeb. subsp. *divaricata*, and *Veronica multifida* L., and *Rhamno oleoidis-Quercetum pubescentis* with *Rhamnus lycioides* subsp. *oleoides* (L.) Jahand. & Maire, *Phlomis nissolii* L., *Pilosella cymosa* (L.) F.W. Schultz & Sch. Bip., *Inula montbretiana* DC., *Onobrychis oxyodonta* Boiss., *Pimpinella olivieroides* Boiss. & Hausskn., and *Torilis ucranica* Spreng. However, the new association includes totally different characteristic species which are *Cotoneaster nummularius, Juniperus oxycedrus* subsp. *oxycedrus, and Phleum montanum.* The herb layer of forest-steppes in Central Anatolia is rich in steppe species due to open forest canopy. The layer is also supported by forest-steppe specialists and this heterogeneity reveals the forest-steppe associations that have low floristic similarity. Moreover, some factors such as altitude and micro-topography may also play important role in dissimilarity of the communities. Interestingly, the *Cotoneastro nummulariae-Quercetum pubescentis* has the sub-association like *Rhamno oleoidis-Quercetum pubescentis* in Melendiz Mountain that is dominated by *Quercus trojana.* However, neither of the sub-associations include common characteristic species.

The riparian habitats serving as a bridge between terrestrial and aquatic ecosystems play an important role in transportation of nutrient, sediment, pollen, organic matter, organisms, and water (Naiman & Decamps 1997). In this respect, riparian habitats are the most dynamic parts of the landscape. The species of *Salix* L., *Populus* L., and *Tamarix* L. species usually dominate the riparian vegetation. A riparian forest community dominated by *Populus nigra* was described in the study area. The new riparian association, *Pastinaco sativae-Populetum nigrae,* occurs on calcareous and non-saline soils with average phosphorous and organic matter content and low nitrogen amount. It extends towards the northwest and southeast of the riverbank in Narköy. The *Pastinaco sativae-Populetum nigrae* was classified under *Populetalia albae* Br.-Bl. ex Tchou 1949, *Populion albae* Br.-Bl. ex Tchou 1949 comprising Mediterranean and sub-Mediterranean riparian gallery forests of the class *Alno glutinosae-Populetea albae* that comprises generally riparian gallery forest in Euro-Siberian and Mediterranean region. Furthermore, the class encompasses azonal alluvial forests of Europe, North Africa, and the western regions of the Middle East, previously classified within the *Querco-Fagetea* Br.-Bl. et Vlieger in Vlieger 1937 without considering attitude of zonality or azonality (Mucina et al. 2016). Since there is a lack of information on riparian vegetation in Anatolia, any *Populus nigra* dominated association has not been reported in Turkey before. Therefore, this association is the first poplar-dominated riparian association described in Turkey. Only, two riparian associations dominated by *Salix alba and Populus alba* L. were described in the Porsuk River in Eskişehir province and Ihlara valley in Aksaray province in Turkey (Kaya & Cansaran 2015, Özdeniz et al. 2016). Among these associations the highest floristic similarity (14.63%) was found with *Populetum albae* in Porsuk River. Although both were classified in the same alliance, the floristic similarity is quite low. *Populetum albae* composed of species such as *Crataegus monogyna* Jacq. var. *monogyna, Urtica dioica* L., and *Rosa canina* L. with high frequencies. On the other hand, *Pastinaco sativae-Populetum nigrae,* which was described in the study area, is composed of characteristic species such as *Pastinaca sativa* L. subsp. *urens* (Req. Ex Gren. & Godr.), *Elaeagnus angustifolia* L., *Mentha longifolia* subsp. *thyphoides* (Briq.) Harley. Also, *Fraxinus angustifolia* subsp. *oxycarpa* (Willd.) Franco & Rocha Afonso and *Phragmites australis* (Cav.) Trin. ex Steud. is not found in the association as in *Populetum albae.* On the other hand, some *Populus nigra* dominated associations were described in Europe such as *Ligustro-Populetum nigrae*, *Carduo crispi-Populetum nigrae*, and *Salici neotrichae-Populetum nigrae* (Schnitzler 1996, Makra 2005, Costa et al. 2011, Poldini et al. 2011). The floristic similarity of *Pastinaco sativae-Populetum nigrae* with all these communities was quite low.

Phragmites australis community is distributed on the shoreline of Narlıgöl, which is intensely covered with *P. australis,* because this species shows high growth and reproduction success, and is a mono-dominant species. It usually prevents distribution of other species (Uddin & Robinson 2017). Also, *P. australis* was considered as an important indicator of the accumulation of nutrient contents in water and it can be adapted to anaerobic conditions and soils with a pH range of 3.7 and 8.7 in eutrophic and mesotrophic water (Othman et al. 2014). That *Phragmites* communities are distributed around the lake and the fact that they are not present in the riparian area of the study area may indicate a higher nutrient accumulation in the water. In the study area, the community cannot be described at association level due to poor species composition. Although it includes some characteristic species of the class *Phragmito-Magnocaricetea* Klika in Klika & Novák 1941 and the order *Phragmitetalia* Koch 1926, characteristic species are not sufficient to define a new association.

In brief, four vegetation types were determined including steppe, forest-steppe, riparian, and shoreline in the study area. Based on classification and analysis of floristic composition of the communities, we propose the following the syntaxonomical list:

Phragmito-Magnocaricetea Klika in Klika et Novak 1941
Unit 1: *Phragmites australis* (Cav.) Trin. ex Steudel community
Alno glutinosae-Populetea albae P. Fukarek et Fabijanić1968
Populetalia albae Br.-Bl. ex Tchou 1949
Populion albae Br.-Bl. ex Tchou 1949
Unit 2: *Pastinaco sativae-Populetum nigrae* ass. nov. hoc loco
Quercetea pubescentis (Oberd. 1948, Doing- Kraft 1955) Scamoni & Passarge 1959
Querco cerridis-Carpinetalia orientalis Quézel, Barbéro & Akman 1980
Quercion anatolicae Akman, Barbéro & Quézel 1979
Cotoneastro nummulariae-Quercetum pubescentis ass. nov. hoc loco
Unit 3: *quercetosum trojanae* subass. nov. hoc loco
Unit 4: *typicum* subass. nov. hoc loco
Astragalo microcephali-Brometea tomentelli Quézel 1973
Onobrychido armenae-Thymetalia leucostomi Akman, Ketenoğlu & Quézel 1985
Phlomido armeniacae-Astragalion microcephalii Akman, Ketenoğlu, Quézel, Demirörs, 1984
Unit 5: *Astragaletum plumoso-microcephalii* ass. nov. hoc loco

Ecology and plant diversity

Vegetation types in the study area demonstrate clear differences in terms of ecological conditions. Increasing continental influence depending on altitude is very effective on steppe and forest-steppe vegetation. In addition, moisture and nutrient were the most important ecological factors on riparian and shoreline vegetation at lower altitudes. These differences were also showed by average indicator values for nutrient, moisture, and continentality. Average EIVs are more prominent among vegetation types than associations. However, calibration and assignment of indicator values pertaining to Central Anatolia may give better discriminations. Furthermore, it is observed that grazing density is the highest on steppe vegetation in the study area. The amount of humus in the soil is so low in the steppe which can be explained by heavy grazing (Dengler et al. 2012).

The forest-steppe and its sub-associations have the highest species diversity in the study area and the steppe association does not lag behind in plant diversity from the forest-steppe association, as well (Figure 8). Forest-steppes can be described as ecotones in which the environment often rapidly alters with regard to abiotic and biotic factors and the gene flow between populations is high and this lead to increase richness and abundance of the species. The forest-steppes can be thought a synthesis of two different habitats because the floristic composition of the forest-steppe in Central Anatolia is comprised of both steppe species and forest-steppe specialists. Even, the edges of forest-steppes can contain their own edge-related species besides the species in interior parts of forest-steppe and steppe (Bátori et al. 2018, Erdős et al. 2019). The plant diversity in steppe depends on various drivers, particularly such as soil types, geomorphology, and microclimate (Ambarlı et al. 2016). The lowest species diversity is in the *Phragmites australis* community. *P. australis* does not allow other species to occur in the shoreline because it effectively resists invasion. Moreover, habitat disturbances such as high evapotranspiration, eutrophication, and litter and sediment accumulation promote the expansion of *P. australis* (Robert 2016).

A semi-arid cold Mediterranean climate prevailing in the study area predominantly allows the development of steppe and forest-steppe vegetation. Steppe vegetation comprises many spiny cushion-like plants of hemicryptophytes, chamaephytes, and perennial *graminoids* adapted to harsh climate conditions (cold climate, low precipitation, and long dry season) (Djamali et al. 2012). Therophytes can also adapt to drought, shortage of precipitation and very dynamic ecosystems indicating anthropogenic factors such as grazing or pollution (Campos et al. 2004, Pantera et al. 2009, Bloch-Petersen et al. 2006). The dominance of hemicryptophytes and therophytes may indicate the adaptation of the plants to arid conditions in the study area that is also under human-induced degradation. For instance, *Phragmites australis* community, which is under grazing degradation, was composed of many therophytes. The dominance of phanerophytes and cryptophytes in moist areas also shows that topography and microclimate are effective on the distribution of plant communities in some part of the study area. At higher altitudes, Iran-Turanian and Mediterranean elements often spread over open areas and steppes, whereas Euro-Siberian elements are distributed in humid areas and meadows. Therefore, the number of Irano-Turanian elements, hemicryptophytes, and chamaephytes is higher in *Astragaletum plumoso-microcephalii* and *Cotoneastro nummulariae-Quercetum pubescentis* followed by Mediterranean elements. However, the number of Euro-Siberian elements, phanerophyte, and hemicryptophyte was higher in *Pastinaco sativae-Populetum nigrae* riparian vegetation. Since steppe and forest-steppe vegetation covers most of the study area, Irano-Turanian elements are represented by a high proportion.

Widespread human-induced degradation and ongoing habitat loss resulted in steppes being one of the most threatened grassland types in the world (Török et al. 2016). Today, Anatolian steppes are facing serious problems such as overgrazing, soil erosion, intensive farming, and incorrect forestation practices (Conde et al. 2002). This excessive degradation on the steppe and forest-steppe vegetation with their prominent biodiversity stresses the need for their conservation and restoration (Erdős et al. 2018). A small part of the Anatolian Biogeographical Region (1.5%) was defined as protected areas, but there is no comprehensive initiative to protect biodiversity for the remaining steppe areas (Ambarlı et al. 2016). The development and proper implementation of management programs such as the Rangeland Act and suitable afforestation plans should be the first step for the conservation of the Anatolian steppes. Further, these conservation efforts for steppes are considerably dependent on awareness of local people. Therefore, an integrative program providing collaboration among the government, local people, and scientists is required. Recently, the project of national and regional steppe conservation strategy supported by FAO/GEF can be a good example for this type of integrative program (FAO 2016).

A feasible conservation attempt requires the knowledge on vegetation structure of forest-steppe regions. Indeed, as it was stressed by many authors, there is somewhat of a gap concerning steppe and forest-steppe vegetation of Central Anatolia due to the areas not yet surveyed. Although having covered a small area, the study makes a significant contribution to the understanding of Central Anatolian steppe, forest-steppe, and wetland vegetation, its structure, ecology, and species richness. This information will promote to the preparation of detailed vegetation maps and constitute core knowledge for management plans and conservation actions. Therefore, we believe that this vegetation study is valuable and an important stage to bring about an insight of vegetation change in Anatolia in the future.

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