



The problem of classification of the *Ulmus* and *Armeniaca* plant communities of Dauria (Southeastern Siberia, Russia)

Nikolai B. Ermakov

Nikolai B. Ermakov
e-mail: brunnera@mail.ru

Nikitsky Botanical Garden – National Scientific Center RAS, Yalta, Nikita, Crimea Republic, Russia

Vernadsky Crimean Federal University, Simferopol, Crimea Republic, Russia

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ABSTRACT

Classification of hemi-xerophilous low tree and shrub communities dominated by *Ulmus pumila*, *U. macrocarpa*, *Armeniaca sibirica* using the Braun-Blanquet approach was performed. All communities were included in the class *Ulmetea pumilae* Hilbig et Narantuya 2016, order *Ulmetalia pumilae* Hilbig et Narantuya 2016, alliances *Ulmion pumilae* Mirkin et al. ex Hilbig 2000, *Spiraeo pubescentis-Ulmion macrocarpae* all. nova hoc loco and associations *Sambuco manshuricae-Ulmum macrocarpae* ass. nova hoc loco, *Spiraeo pubescentis-Ulmum macrocarpae* ass. nova hoc loco и *Ulmo pumilae-Armeniacetum sibiricae* ass. nova prov. Ecological peculiarities and differences of new associations and alliance were demonstrated in results of DCA ordinations. An original approach for classification of hemi-xerophilous types of low trees and shrubs communities with transitional floristic-phytocoenotic features based on the physiognomy as a main criterion for the higher syntaxonomis category establishment is proved.

Key words: vegetation, forests, shrub communities, classification, Eastern Asia

РЕЗЮМЕ

Ермаков Н.Б. К проблеме классификации растительных сообществ *Ulmus* и *Armeniaca* из Даурии.

Проведена классификация гемиксерофильных сообществ низких деревьев и кустарников с доминированием *Ulmus pumila*, *U. macrocarpa*, *Armeniaca sibirica* с использованием метода Браун-Бланке. Все сообщества отнесены в состав класса *Ulmetea pumilae* Hilbig et Narantuya 2016, порядка *Ulmetalia pumilae* Hilbig et Narantuya 2016, двух союзов – *Ulmion pumilae* Mirkin et al. ex Hilbig 2000, *Spiraeo pubescentis-Ulmion macrocarpae* all. nova hoc loco и четырех ассоциаций *Sambuco manshuricae-Ulmum macrocarpae* ass. nova hoc loco, *Spiraeo pubescentis-Ulmum macrocarpae* ass. nova hoc loco, *Menispermum daurici-Ulmum pumilae* ass. nova hoc loco и *Ulmo pumilae-Armeniacetum sibiricae* ass. nov. prov. Экологические свойства и различия впервые описанных синтаксонов ранга ассоциации – союзы продемонстрированы с использованием метода DCA ординации. При классификации гемиксерофильных типов древесно-кустарниковой растительности с промежуточными флоро-фитоценоотическими признаками обоснован и реализован подход использования физиономического признака (структуры сообщества) в качестве ведущего при установлении высшей синтаксономической категории – класса.

Ключевые слова: растительность, леса, кустарниковые сообщества, классификация, Восточная Азия

INTRODUCTION

At present, classification of the sub-oceanic part of the East Asian non-tropical vegetation within the scopes of Braun-Blanquet approach is well developed due to publications by Miyawaki 1980-1989, Song 1988, Galkina & Petelin 1990, Kim 1990, 1992, Gumarova 1993, Takeda et al. 1994, Akhtiamov 1995, Krestov & Nakamura 2002, Kolbek et al. 2003, Krestov et al. 2006, Ermakov & Krestov 2009, Krestov et al. 2015, etc. However publications on vegetation syntaxonomy for the inner continental part of Eastern Asia (namely north-eastern China, Inner Mongolia and Dauria) are still sparse. Most of them focus only on certain vegetation types of forests, steppes, and meadows (Ermakov 1997, 2003, Anenkhonov 2000, Ermakov et al. 2000, Korolyuk et al. 2002, 2013, Krestov et al. 2006, Ermakov

& Krestov 2009). One of the debatable issues of Daurian vegetation classification observed both in the traditional dominant (Sukachev 1928) and in the Braun-Blanquet approaches is the position of hemi-xerophilous shrubberies in hierarchical systems. This vegetation type, like its analogs in other regions of Northern Eurasia, is characterized by transitional features of phytocoenotic structure, floristic composition and ecology between steppes and forests. Among a variety of hemi-xerophilous shrubberies there are peculiar communities dominated by species of the genera *Armeniaca* and *Ulmus*. They are characterized by a higher layer (height of 2–7 m and cover of 15–70%) consisting of *Ulmus macrocarpa*, *U. pumila*, *U. japonica* and *Armeniaca sibirica* existing in life forms of tall shrubs or small trees depending on environments. Lower shrub layer (height 0.5–1 m, cover

10–40%) is formed by species of *Spiraea*, *Cotoneaster*, *Ribes* genera. Shade tolerant and drought resistant steppe xerophytes among which there are many obligate and facultative petrophytes predominate in the grass layer (average height 17–30 cm, cover 40–70%).

Ulmus and *Armeniaca* shrubberies representing petrophilous element of forest-steppe and steppe mountain belts attracted a special attention of scientists, who studied diversity, ecology and geography of Daurian vegetation. Some researchers following the traditional dominant approach to classification attributed *Ulmus* and *Armeniaca* communities to the “steppe vegetation type” as special “formations” (Reshchikov 1961, Lavrenko et al. 1991, Dulepova 1993). Other researches (Kamelin 1987, 2005, Belikovitch & Galanin 2006, Namzalov 2012, Kholboyeva et al. 2015) identified them as Mediterranean vegetation type – “shiblyak” taking into account the special phytocoenotic feature, namely predominance of special life forms – drought resistant low deciduous trees and tall shrubs in the higher layer. These authors considered *Ulmus* and *Armeniaca* shrubberies of Daurian-Manchurian province as an example of relic warmth-loving forest vegetation widespread in Eastern Asia in Tertiary Period and give them a higher syntaxonomic rank.

At present, the *Ulmus* and *Armeniaca* shrubberies classification using the Braun-Blanquet method was dominantly developed in Eastern Mongolia (Mirkin et al. 1986, Hilbig 1990, 1991, 2000, Hilbig & Narantuya 2016). Mirkin et al. (1986) proposed a special alliance *Ulmion pumilae* Mirkin et al. 1986 (nom. nud.) within the order *Populetalia laurifolio-suaevolentis* Mirkin et al. 1986 uniting the flood-plain forests. Hilbig (1990) described several associations of hemi-xerophilous shrubberies from Eastern Mongolia: *Spiraeo aquilegifoliae-Ulmetum pumilae*, *Stipo sibiricae-Ulmetum pumilae*, *Amygdalo pedunculatae-Spiraeetum aquilegifoliae*, *Spiraeo mediae-Cotoneastretum melanocarpi*, *Caragano bungei-Spiraeetum hypericifoliae*. Later, Hilbig (2000) validated these associations and placed *Ulmus pumila* dominated communities in the special alliance *Ulmion pumilae* Mirkin et al. ex Hilbig 2000 while shrubberies dominated by steppe species *Spiraea aquilegifolia*, *Amygdalus pedunculata* were attributed to the alliance *Spiraeion aquilegifoliae* Hilbig 2000. After that Hilbig & Narantuya (2016) included both these alliances in the special class *Ulmetea pumilae* Hilbig et Narantuya 2016 representing East Asian hemi-xerophilous shrubby vegetation. However, in the latest publication, authors confined themselves to a formal description of the new class and gave a very poor its description.

The aim of the present study is to classify the *Ulmus* and *Armeniaca sibirica* shrubberies from Eastern Dauria using the Braun-Blanquet approach and provide their syntaxonomic analysis.

Environment

Dauria is geographical province of Eastern Eurasia. It is located in upper part of the Amur river basin, between eastern Siberia and inner Mongolia. Dauria is mountain region with system of low ridges (altitudes up to 1550 m a.s.l.) separated by wide river basins and intermountain hollows. The climate of Dauria is characterized by a high degree of continentality. The summer is short and hot. The mean July

temperature is 19–20°C, effective heat sum for the period amounts to 1800°C. The winter here, due to stable anticyclone, is very cold, with very shallow snow. The mean January temperature is –28 – –30°C, the annual air temperature amplitude is 44–48°C. The total annual precipitation is 320–350 mm, 300–325 mm of which fall in summer (Sochava 1967). The precipitation regime is determined by the Pacific monsoon, influence of which spreads westwards up to the Yablonevy Range (Mikhailov 1961). The relief of the territory is presented by a combination of lower ranges (up to 1550 m) and wide river valleys (Florensov 1974). As thermophilous species, *Ulmus macrocarpa*, *U. pumila* and *Armeniaca sibirica* occur in the warmest and moderately moistened sites on southern macro-slopes of low ranges at altitudes from 250 to 1200 m, within steppe and forest-steppe belts.

MATERIAL AND METHODS

The shrubby vegetation of rock outcrops and talus slopes was sampled in the forest-steppe and steppe belts of the eastern part of Dauria. The focus was on vegetation dominated by hemi-xerophilous small trees and tall shrubs. Selected sites were documented with relevés, i.e. plots of 100 m² in size, where all the vascular plants, and also bryophytes and macrolichens were recorded and assigned a cover-abundance value of the Braun-Blanquet scale. A total of 22 relevés were sampled. Additional 15 relevés of *Armeniaca sibirica* shrubberies from Eastern Dauria (the Onon river basin) were taken from available literature (Belikovitch & Galanin 2006). The classification of plant communities was carried out using the Braun-Blanquet approach (Westhoff & van der Maarel 1978). The relevés were stored in the TURBOVEG database (Hennekens & Schamineè 2001) and classified by TWINSPAN (Hill 1979). For every degree of the Braun-Blanquet scale, a new pseudospecies was introduced in TWINSPAN, i.e. classification used cover-abundance information. In order to check the quality of the resulting classification, another classification of the dataset was performed by the cluster analysis, using Ward's method and Euclidean distance, from the STATISTICA software. The values of cover-abundance on the Braun-Blanquet scale were used as input data in this analysis. Detrended correspondence analysis (DCA) ordination using DECORANA (Hill & Gauch 1980) was carried out in order to show the position of the already distinguished vegetation types along the main gradients. Additional 10 relevés of *Ulmus pumila* dominated communities of the association *Spiraeo aquilegifoliae-Ulmetum pumilae* Hilbig 2000 from neighboring area of Eastern Mongolia (Hilbig 1990) were used in cluster analysis and ordination for evaluation of floristic similarities and differences between Daurian and Mongolian syntaxa. The classification of Daurian *Ulmus* and *Armeniaca* shrubberies is presented in a species-by-site table, in which diagnostic species were determined for each vegetation unit. Species with an indicator value higher than 40 were considered diagnostic. Species names follow the list of vascular plants of the former USSR (Cherepanov 1995; electronic version prepared by D. Geltman). Nomenclature of syntaxa follows the rules of the International Code of Phytosociological nomenclature (Weber et al. 2000).

RESULTS

Based on the TWINSPAN results, 5 groups of relevés from Dauria and Eastern Mongolia were distinguished, each with a distinct floristic composition and clear ecological interpretation. The similarity structure among these groups is shown in the cluster analysis dendrogram (Fig. 1), which corresponds well to the accepted classification, thus confirming its robustness. After comparison of these groups with the phytosociological literature, we suggest their syntaxonomic interpretation into one class and five associations.

The proposed syntaxonomic scheme is as follows:

Cl. *Ulmetea pumilae* Hilbig et Narantuya 2016

Ord. *Ulmetalia pumilae* Hilbig et Narantuya 2016

All. *Spiraeo pubescentis-Ulmion macrocarpae* **all. nova hoc loco**

Ass. *Sambuco manshuricae-Ulmetum macrocarpae* **ass. nova hoc loco**

Ass. *Spiraeo pubescentis-Ulmetum macrocarpae* **ass. nova hoc loco**

All. *Ulmion pumilae* Mirkin et al. ex Hilbig 2000

Ass. *Menispermum daurici-Ulmetum pumilae* **ass. nova hoc loco**

Ass. *Ulmo pumilae-Armeniactum sibiricae* **ass. nova prov.**

Ass. *Spiraeo aquilegifoliae-Ulmetum pumilae* Hilbig 2000

Ulmetea pumilae Hilbig et Narantuya 2016

Diagnostic species: *Ulmus pumila*, *U. macrocarpa*, *Armeniaca sibirica*, *Spiraea pubescens*, *S. aquilegifolia*, *Sambucus manshurica*, *Rhamnus parvifolia*, *R. erythroxydon*, *R. davurica*, *Crataegus daburica*, *Ribes diacantha*, *Pentaphylloides parvifolia*, *Artemisia gmelinii*, *Sedum aizoon*, *Aquilegia viridiflora*, *Vincetoxicum sibiricum*, *Lophanthus chinensis*, *Menispermum dauricum*, *Leonurus sibiricus*, *Rubia cordifolia*, *Polygonatum humile*, *P. sibiricum*, *Potentilla tanacetifolia*, *Saposhnikovia divaricata*, *Clematis hexapetala*.

The class originally described by Hilbig & Narantuya (2016) in Eastern Mongolia includes East Asian hemi-xerophilous petrophytic shrubby vegetation. At present, there is poor information about this vegetation type widespread in semi-arid climatic sector of mountain systems in Manchurian-Daurian region. Communities of the *Ulmetea pumilae* occupy azonal habitats – weathered southern slopes with exposed rocks of different lithology, stable screes, ravines and not-flooded parts of river valleys. They represent one of the most thermophilous vegetation type of the Daurian forest-steppe. Across the entire geographic range, these communities are in contact with the *Cleistogenetea squarrosae* Mirkin et al. ex Korotkov et al. 1991 steppes predominating in zonal sites with well-developed soils. An important feature of the class is a leading phytocoenotic role of drought-adapted (hemi-xerophilous) shrubs (sometimes they accept a low tree life form) – *Ulmus pumila*, *U. macrocarpa*, *Armeniaca sibirica*. These characteristic species of the *Ulmetea pumilae* form a higher (1–5 m) layer with a cover 25–70 %. Typical xeric shrub and semi-shrub species (*Spiraea aquilegifolia*,

S. pubescens, *Artemisia gmelinii*, *Lespedeza juncea*) form well developed layer up to 0.8–1.5 m high. Herb species are represented by perennial, obligate or facultative petrophyllous plants (*Patrinia rupestris*, *Potentilla tanacetifolia*, *Rubia cordifolia*, *Sedum aizoon*) as well as by species widespread in surrounding zonal steppes (*Carex pediformis*, *Agropyron cristatum*, *Clematis hexapetala*, *Carex korsbinskyi*, *Acnatherum sibiricum*). Bryophytes and lichens never form a distinct layer. Species richness usually varies between 29–60 species per relevé. Within the class *Ulmetea pumilae* we distinguish one order, *Ulmetalia pumilae* (with the same character and differential species as the class), and two alliances, *Ulmion pumilae* and *Spiraeo pubescentis-Ulmion macrocarpae*.

Ulmion pumilae Mirkin et al. ex Hilbig 2000

The alliance unites communities with predominance of *Ulmus pumila* and *Armeniaca sibirica* occurring in moderately petrophytic habitats in forest-steppe and steppe zones. They occupy lower concave parts of gentle mountain slopes with shallow soils, ravines and higher terraces of river valleys. Besides these two above mentioned species, diagnostic combination of the alliance according to Hilbig & Narantuya (2016) includes *Padus asiatica*, *Malus baccata*, *Ribes diacantha*, *Rhamnus erythroxydon*, *Rubia cordifolia*, *Thalictrum squarrosum*, *Stipa sibirica*, *Asparagus daburicus*. At present, the *Ulmion pumilae* is represented by two associations in Dauria. The relevés of the association *Spiraeo aquilegifoliae-Ulmetum pumilae* Hilbig 2000 as nomenclature type of the *Ulmion pumilae* were added to cluster analysis (Fig. 1) to demonstrate floristic relations of described new units.

Menispermum daurici-Ulmetum pumilae **ass. nov. hoc loco** (Tables 1,2, relevés 18–23)

Diagnostic species: *Menispermum dauricum*, *Potentilla bifurca*, *Artemisia mongolica*, *Leonurus sibiricus*, *Rhamnus parvifolia*, *Viola variegata*, *Potentilla longifolia*, *Ribes diacantha*, *Malus baccata*, *Erysimum flavum*, *Elymus daburicus*, *Alyssum lenense*, *Sisymbrium heteromallum*.

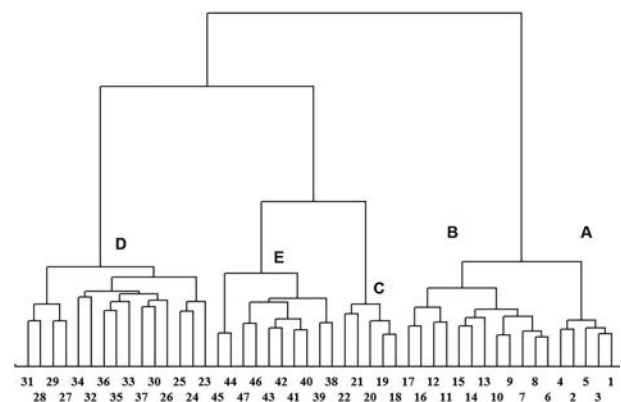


Figure 1 Dendrogram of 47 relevés of *Ulmus macrocarpa*, *U. pumila*, *Armeniaca sibirica* communities and syntaxa hierarchy (Ward's method, Euclidian distances). A – ass. *Sambuco manshuricae-Ulmetum macrocarpae*, B – ass. *Spiraeo pubescentis-Ulmetum macrocarpae*, C – ass. *Menispermum daurici-Ulmetum pumilae*, D – ass. *Ulmo pumilae-Armeniactum sibiricae*, E – ass. *Spiraeo aquilegifoliae-Ulmetum pumilae*

Table 2. Ecological, phytocoenotic and geographical characteristics of relevés of new associations from Table 1.

relevé nr.	date	relevé area (m ²)	altitude (m)	aspect (degrees)	slope (degrees)	cover shrub layer (%)	cover herb layer (%)	height (highest) shrubs (m)	height lowest shrubs (m)	aver. height (high) herbs (cm)	aver. height lowest herbs (cm)	field_relevé code	latitude	longitude
1	28.08.2004	100	779	190	35	55	5	1.5	0.9	0	30	94NE-04	51°01'06"	115°36'39"
2	30.08.2004	100	726	290	25	45	5	2	1.4	0	40	95NE-04	50°24'10"	118°07'21"
3	30.08.2004	100	726	200	15	55	7	3	2	0	40	96NE-04	50°24'10"	118°07'21"
4	30.08.2004	100	726	200	40	40	10	3	1.9	0	43	97NE-04	50°24'10"	118°07'21"
5	30.08.2004	100	731	180	7	55	15	3.5	2.2	60	48	98NE-04	50°24'08"	118°08'15"
6	30.08.2004	100	720	130	45	55	10	1.4	0.5	40	21	99NE-04	50°24'08"	118°08'15"
7	30.08.2004	100	724	170	50	60	10	1.1	0.5	35	20	100NE-04	50°24'08"	118°08'15"
8	30.08.2004	100	715	100	60	50	15	0.8	0.4	45	25	101NE-04	50°37'15"	118°26'40"
9	31.08.2004	100	702	240	40	50	15	0.8	0.4	30	18	102NE-04	50°38'01"	118°25'47"
10	31.08.2004	100	702	250	35	65	10	1.1	0.5	40	12	103NE-04	50°38'01"	118°25'47"
11	31.08.2004	100	634	160	30	60	20	1.6	1.2	48	35	104NE-04	50°54'49"	118°36'43"
12	31.08.2004	100	634	180	20	70	20	1.8	1.2	40	35	105NE-04	50°54'49"	118°36'43"
13	31.08.2004	100	707	170	40	50	20	3	1.5	35	22	106NE-04	50°56'43"	119°18'55"
14	01.09.2004	100	706	170	30	45	20	1.2	0.5	35	18	107NE-04	51°01'46"	119°11'05"
15	01.09.2004	100	706	180	45	70	20	1.5	0.7	30	17	108NE-04	51°01'46"	119°11'05"
16	01.09.2004	100	698	180	30	65	20	3	0.9	50	28	109NE-04	51°18'00"	119°34'53"
17	01.09.2004	100	698	170	40	50	25	3	0.6	58	38	110NE-04	51°18'00"	119°34'53"
18	03.09.2004	100	661	180	45	20	10	1.4	1	45	28	113NE-04	51°45'50"	117°13'50"
19	03.09.2004	100	661	200	50	25	20	2	1.3	50	40	114NE-04	51°45'50"	117°13'50"
20	03.09.2004	100	661	160	45	25	20	2	1.4	45	35	115NE-04	51°45'50"	117°13'50"
21	04.09.2004	100	661	210	45	25	20	2.5	0.9	48	17	116NE-04	51°45'50"	117°13'50"
22	04.09.2004	100	654	210	30	50	30	3	1.1	48	20	117NE-04	51°45'48"	117°14'42"

Holotypus: relevé 20, Tables 1, 2.

The association was described from forest-steppe belt of south-eastern Dauria where it occupies lower parts of the weathered southern slopes with gravel substrates of hills and low mountains facing the Onon river valley. *Ulmus pumila* forms a shrub layer with height of 0.8–1.3 m and cover 40–60 %. The main peculiarity of community is high constancy values of Daurian-Manchurian and Central Asian petrophilous shrub and herb species representing diagnostic species group. Besides, characteristic xeric plants of zonal East-Asian steppes occur occasionally there.

***Ulmo pumilae-Armeniacetum sibiricae* ass. nov. prov.** (Tables 1,2, relevés 24–37)

Diagnostic species: *Armeniaca sibirica*, *Potentilla acervata*, *Filifolium sibiricum*, *Dracocephalum nutans*, *Ixeridium gramineum*, *Aster tataricus*, *Stemmacantha uniflora*, *Helictotrichon schellianum*, *Spiraea media*, *Silene jeniseensis*, *Carex duriuscula*, *Aconogonon divaricatum*, *Spodiopogon sibiricus*, *Stellera chamaejasme*, *Stevnia cheiranthoides*, *Iris uniflora*.

Belikovitch & Galanin (2006) described communities with predominance of *Ulmus pumila* and *Armeniaca sibirica* as different “types”. However we did not distinguish any essential floristic differences between these two types after TWINSPAN treatment of whole set of relevés. Therefore based on published data we preliminarily describe one association *Filifolio sibiricae-Armeniacetum sibiricae* representing hemi-xerophilous shrub communities from forest-steppe belt of the Onon river basin. They occupy the ledges of the Onon river terraces and depressions on southern mountain

slopes with shallow soils on weathered rock outcrops. The higher layer of community (up to 2.5 m) is formed by *Armeniaca sibirica*, *Ulmus pumila*, *Malus palassiana* sometimes with admixture of *U. macrocarpa*. Shrub layer (with the height 0.5–1.2 m) consists of *Spiraea aquilegifolia* and *S. media*. Herb layer is characterized by cover 30–50 % and species richness 30–60 species per plot. Characteristic feature of the association is a higher role of moderately xerophilous species of zonal Daurian-Manchurian steppes – *Aster tataricus*, *Potentilla acervata*, *Stemmacantha uniflora*, *Aconogonon divaricatum*, *Filifolium sibiricum*. They indicate more favorable soil conditions in comparison with the sites of previous association.

***Spiraeo aquilegifoliae-Ulmetum pumilae* Hilbig 2000**

Diagnosis of this association from Eastern Mongolia and relevés table were published in Hilbig (1990). Results of cluster analysis (Fig. 1) demonstrated floristic similarities of the *Spiraeo aquilegifoliae-Ulmetum pumilae* with two Daurian associations – *Menispermo daurici-Ulmetum pumilae* and *Ulmo pumilae-Armeniacetum sibiricae*. This suggests that all these three associations should be included in one alliance *Ulmion pumilae* Mirkin et al. ex Hilbig 2000 (*Spiraeo aquilegifoliae-Ulmetum pumilae* was chosen by Hilbig (2000) as the alliance holotypus).

***Spiraeo pubescentis-Ulmion macrocarpae* all. nov. hoc loco** (Tables 1, 2, relevés 1–17)

Diagnostic species: *Ulmus macrocarpa* (transgr.), *Spiraea pubescens*, *Polygonatum sibiricum*, *Euphorbia fischeriana*, *Lespedeza davurica*, *Scutellaria baicalensis*, *Vincetoxicum sibiricum*.

Holotypus: association *Spiraeo pubescentis-Ulmetum macrocarpae*.

Comparative analysis of communities from Dauria and Eastern Mongolia as well as results of cluster analysis (Fig. 1) demonstrated essential differences in floristic compositions of hemi-xerophilous shrubberies dominated by two elm species – *Ulmus macrocarpa* and *U. pumila*. It indicates important ecological distinctions of elm communities as well. *Ulmus macrocarpa* shrubberies occur in south faced slopes with stable screes and exposed rocks of different lithology. Screes are formed of large stones of metamorphic or granitic rocks up to 60 cm in diameter. Soil cover is fragmental and shallow. Shrubberies dominated by *Ulmus pumila* and *Armeniaca sibirica* occupy more gentle mountain slopes, pediments, ravines and river valleys with deluvial deposits consisting of clay, small stones and gravels. These substrates are more favorable for soil cover development. Distinctions in soils conditions of *Ulmus macrocarpa* and *Ulmus pumila* shrubberies result in the fact that they occupy different landforms within the same landscapes in Daurian forest-steppe and steppe. Besides, *Ulmus macrocarpa* communities are closely related to the Monsoon climate and western limit of their range runs in Eastern Dauria. Unlike it the *Ulmus pumila* community range extends westward to Central Asia with more arid and ultracontinental climate.

Ulmus macrocarpa shrubberies were included in special alliance *Spiraeo pubescentis-Ulmion macrocarpae* comprising two associations.

***Sambuco manshuricae-Ulmetum macrocarpae* ass. nov. hoc loco** (Tables 1,2, relevés 1–5)

Diagnostic species: *Artemisia messerschmidiana*, *Sambucus manshurica*, *Urtica cannabina*, *Aquilegia viridiflora*, *Lophanthus chinensis*, *Sorbaria sorbifolia*.

Holotypus: relevé 3, Tables 1, 2.

The association occurs in forest-steppe belt of Eastern Dauria where it occupies moderately humid parts of southern steep stony slopes adjacent to river valleys at altitudes 725–730 m. *Ulmus macrocarpa* in a life form of small tree forms a higher layer with a height up to 3.5 m and cover 10–35 %. Shrub layer (height 0.8–2.2 m, cover 40–55 %) consists of drought adapted petrophilous species: *Sorbaria sorbifolia*, *Spiraea pubescens*, *S. aquilegifolia*, *Artemisia messerschmidiana*. Herb layer is poorly developed (cover 5–10 %) because of intensive shading from higher strata. It includes moderately mesophilous petropytes: *Aquilegia viridiflora*, *Lophanthus chinensis*, *Polygonatum sibiricum*, *Vincetoxicum sibiricum*, *Rubia cordifolia*, *Stellaria dichotoma* and shade-tolerant steppe species *Paeonia lactiflora*, *Scutellaria baicalensis*, *Polygonatum sibiricum*, *Euphorbia fischeriana*, *Artemisia dracunculus*.

***Spiraeo pubescentis-Ulmetum macrocarpae* ass. nov. hoc loco** (Tables 1,2, relevés 6–17)

Diagnostic species: *Carex pediformis*, *Poa transbaicalica*, *Pardanthopsis dichotoma*, *Thalictrum appendiculatum*, *Lespedeza davurica*, *Leibnitzia anandria*, *Scorzonera austriaca*, *Schizonepeta multifida*, *Aconogonon angustifolium*, *Saussurea saliczifolia*.

Holotypus: relevé 8, Tables 1, 2.

The association is widespread in the forest-steppe belt of Eastern Dauria (the Argun river basin) where it occupies

steep and gentle southern mountain slopes in landscapes dominated by zonal steppes. Community occurs on stable screes formed of large stones of metamorphic or granitic rocks with fragment of shallow soils at altitudes 700–725 m. Association is characterised by well-developed higher layer (height of 1.7–3 m, cover 50–70 %) dominated by *Ulmus macrocarpa*. Second layer with cover 10–35 % and height 0.5–1 m is formed by lower xerophilous shrubs *Spiraea pubescens*, *S. aquilegifolia*, *Cotoneaster melanocarpus*. Herb layer is not well-developed (cover 10–20 %) because of intensive shading, however it is characterized by rather high values of species richness (30–52 species in 100 m²). Xerophilous Daurian-Manchurian plants predominate there however the role of Central and North Asian steppe species (*Carex pediformis*, *Poa transbaicalica*, *Artemisia gmelinii*, *Potentilla tanacetifolia*, *Achnatherum sibiricum*) is essential too.

Ordination

The pattern of floristic differentiation of syntaxonomic units of the *Ulmus* and *Armenica* shrubberies was visualised using DCA ordination. Scatter plots of 37 relevés from Dauria and 10 relevés from Eastern Mongolia are shown in Fig. 2. Axis 1 represents a successive replacement of the major types of East Asian hemi-xerophilous shrubberies in connection with the lithology of the substratum and demonstrates ecological and floristic differences between two alliances – *Ulmion pumilae* and *Spiraeo pubescentis-Ulmion macrocarpae*. Relevés of the *Ulmion pumilae* (including *Ulmus pumila* and *Armeniaca sibirica* plant communities) occurring on small-gravel mixed with loamy soils (3–5) occupy the left-hand part of axis 1; right-hand part of axis 1 is occupied by the communities of the alliance *Spiraeo-Ulmion macrocarpae* (1–2) occurring on stable large-gravel screes and thin loamy soils with rock-outcrops. The set of all three well-separated associations of the alliance *Ulmion pumilae* is observed along axis 2 (Fig. 2). Ecological explanation of this consequence is not clear however it demonstrates a distinct phytogeographical regularities namely increasing participation of East Asian species in the associations set: *Spiraeo aquilegifoliae-Ulmetum pumilae* – *Menispermum daurici-Ulmetum pumilae* – *Ulmion pumilae-Armeniacetum sibiricae*. Probably this association consequence is related to increasing the Pacific monsoon influence from the Khentei mountain system (Eastern Mongolia) to the Argun river basin. Although two associations (1, 2) of the *Ulmion macrocarpae* largely overlap in the space of axes 1 and 2, they are separated into two distinct groups along axis 3: drought-adapted communities of the *Spiraeo pubescentis-Ulmetum macrocarpae* in the upper part (values 0.7–1.5) and moderately drought adapted communities of the *Sambuco manshuricae-Ulmetum macrocarpae* in the lower part (0.2–0.4).

DISCUSSION

Classification of hemi-xerophilous shrubberies is faced with a problem of uncertainty of these communities status in hierarchical system because of their clearly transitional floristic, phytocoenotic and ecological features between forests and grasslands. Therefore the discussions on syntaxonomical position of this vegetation type are related to the fundamental classification problem – a priority in use of

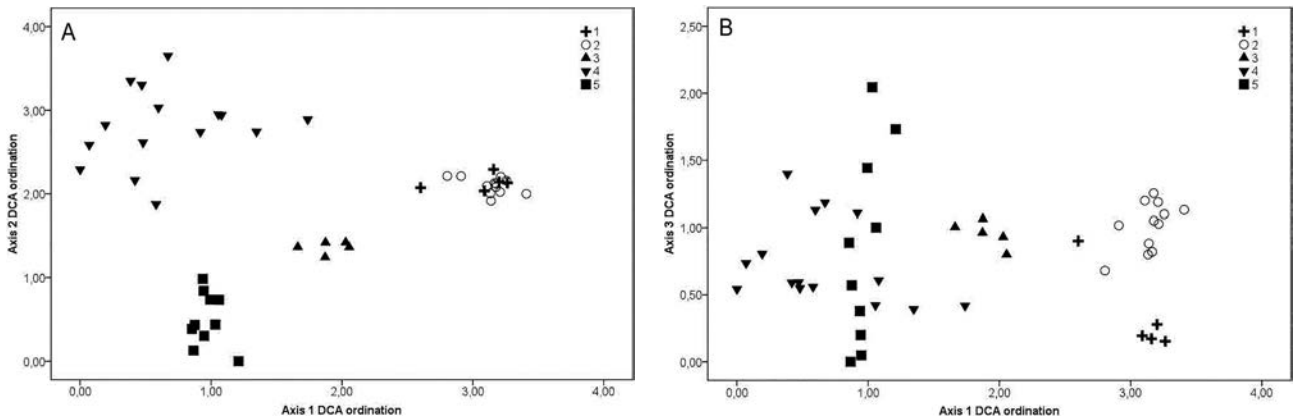


Figure 2 DCA ordination diagram with axes 1 and 2 (A) and axes 2 and 3 (B) of *Ulmus* and *Armeniaca* shrubberies in Dauria and Eastern Mongolia. 1 – *Sambucus manshurica*-*Ulmum macrocarpa*, 2 – *Spiraea pubescens*-*Ulmum macrocarpa* (*Spiraea pubescens*-*Ulmion macrocarpa*), 3 – *Menispermum daurici*-*Ulmum pumilae*, 4 – *Ulmum pumilae*-*Armeniaca sibirica*, 5 – *Spiraea aquilegifolia*-*Ulmum pumilae* (*Ulmion pumilae*).

three main vegetation criteria: floristic composition, physiognomy and ecology. According to the floristic criterion all *Ulmus* and *Armeniaca* communities are very close to East Siberian – Central Asian steppes of the class *Cleistogenetea squarrosae*. The main dominants and constant species found in hemi-xerophilous shrubberies such as *Achnatherum sibiricum*, *Carex korsinskyi*, *Clematis hexapetala*, *Artemisia gmelinii*, *Paeonia lactiflora*, *Lychnis sibirica*, *Carex pediformis*, *Poa transbaikalica*, *Potentilla tanacetifolia*, *Patrinia rupestris*, *Allium anisopodium*, *Lespedeza davurica*, *Pulsatilla turezaninovi* are widespread plants in various associations of zonal and petrophyllous steppes of the *Cleistogenetea squarrosae* (especially in the order *Festucetalia lenensis* Mirkin in Gogoleva et al. 1987). Both phytocoenotic categories are characterised by similar spectra of chorological groups (with predominance of East-Asian and Daurian-Manchurian species). It explains the arguments of those (Reshchikov 1961, Lavrenko et al. 1991, Dulepova 1993), who include *Ulmus* and *Armeniaca* shrubberies in steppe vegetation type as a special subordinated unit – “shrubby steppes”. However higher layer formed by low trees and tall shrubs with cover up to 70 % define the main physiognomic characteristic feature of hemi-xerophilous shrubberies which makes impossible to identify them as steppes. The main dominants *Ulmus pumila* and *U. macrocarpa* take life forms of trees with a height of 2–5 m or tall shrubs up to 1.5 m in environments of forest-steppe and steppe. Moreover these species sometimes achieve a height of 12 m in forest zone (Belikovich & Galanin 2006). Similarly, *Armeniaca sibirica* takes life forms of low tree (up to 10 m) or tall shrub in more xeric sites depending on environments. Average heights of accompanied low trees and shrubs (*Sambucus manshurica*, *Rhamnus parvifolia*, *Spiraea pubescens*, *S. aquilegifolia*, *Ribes diacantha*) vary between 1 and 8 m. Cover values of higher layer are varying within 20 and 90 %. As whole, hemi-xerophilous shrubberies are rather closed communities although separate examples of *Ulmus* and *Armeniaca* shrubs occur in steppes. Light demanding xerophytes of East Asian steppes (*Stipa krylovii*, *Artemisia frigida*, *Agropyron cristatum*, *Cleistogenes squarrosa*, *Poa botryoides*) occur in most *Ulmetea pumilae* associations, however their constancy and cover values are lower compared with zonal steppe communities due to shading from the higher layer.

At the same time, *Ulmus* and *Armeniaca* shrubberies do not demonstrate any essential floristic similarities with mesophilous nemoral birch (*Betula davurica*, *B. platyphylla*) and oak (*Quercus mongolica*) forests of the class *Quercu-Betuletea davuricae* Ermakov et Petelin 1996 occurring in the same forest-steppe landscapes.

In fact, to solve the problem of *Ulmus* and *Armeniaca* shrubberies position in the Braun-Blanquet hierarchical system it is necessary to select the priority between the two classification criteria “floristic” and “physiognomic”. According to principles used in the latest classification system of Europe (Mucina et al. 2016) hemi-xerophyllous communities dominated by tall shrubs were not attributed to “grassland” category. Similarly, some Russian followers of dominant approach (Kamelin 1987, 2005, Belikovich & Galanin 2006, Namzalov 2012, Kholboyeva et al. 2015) did not include *Ulmus* and *Armeniaca* shrubberies in the “steppe vegetation type”. Therefore we accept the concept of Hilbig & Narantuya (2016) about uniting all East Asian hemi-xerophilous low tree and shrub communities in the special class *Ulmetea pumilae* Hilbig et Narantuya 2016 despite of their floristic similarity with steppes of the *Cleistogenetea squarrosae*. In implementing this approach, the characteristic feature of this class is predominance of differential species *Ulmus pumila*, *U. macrocarpa*, *Armeniaca sibirica* in higher layer. Diagnostic species combination of the *Ulmetea pumilae* includes also other East-Asian petrophyllous shrubs *Spiraea pubescens*, *S. aquilegifolia*, *Sambucus manshurica*, *Rhamnus parvifolia*, *R. erythroxydon*, *R. davurica*, *Crataegus daburica*, *Ribes diacantha*, *Dasiphora parvifolia*, semi-shrub *Artemisia gmelinii* and herbs *Sedum aizoon*, *Aquilegia viridiflora*, *Vincetoxicum sibiricum*, *Lophanthus chinensis*, *Menispermum dauricum*, *Leonurus sibiricus*, *Rubia cordifolia*, *Polygonatum humile*, *P. sibiricum*, *Potentilla tanacetifolia*. All these species take an important part in the *Ulmetea pumilae* plant communities unlike the *Cleistogenetea* steppes where they are characteristic only for petrophyllous associations.

Hemi-xerophilous shrubberies similar to the *Ulmetea pumilae* occur in temperate, semi-arid and arid zones. These communities are widespread in Mediterranean and Middle Asian regions where they were described as a special type “shiblyak”. According to the Braun-Blanquet approach si-

milar communities (mantle vegetation) were included in several higher units. In Southern Europe, analogue of the *Ulmetea pumilae* is the class *Crataego-Prunetea* Tx. 1962 (Mucina et al. 2016) comprising shrubberies with predominance of widespread shrubs and low trees in higher layer. The latter class is very diverse and includes four orders and more than 20 alliances. Only the use of the physiognomic criterion facilitated the incorporation of such a large number of floristically varying subordinated units in one highest rank category. South European *Crataego-Prunetea* and Daurian-Manchurian *Ulmetea pumilae* shrubberies can be considered as geographically corresponding vegetation types with a similar physiognomy but formed in different floristic provinces and bioclimatic sectors of Eurasia.

The *Ulmetea pumilae* communities show both some important physiognomic, floristic, ecological similarities and some differences to the class *Artemisio-Berberidetea sibiricae* Ermakov et al. 2006 uniting South Siberian and Central Asian drought-resistant shrubberies of screes and outcrops (Ermakov et al. 2006). However currently we do not have a geographically wide primary data set on phytocoenotic diversity of both classes to make a reasoned syntaxonomic decision about opportunity to combine these two classes into one.

At present, it is not easy to define a correct *Ulmetea pumilae* geographical range because of poor available phytosociological data from inner part of Eastern Asia. However no doubt it has discontinuous outline within the forest-steppe of Dauria (to the east of Lake Baikal), Eastern Mongolia (Hilbig 1990) and inner provinces of North Eastern China (Schmitt 2003). As extrazonal vegetation type the *Ulmetea pumilae* shrubberies penetrate in Sub-Pacific nemoral zone where they occupy steep south-oriented mountain slopes with screes and outcrops of bedrocks (Krestov & Verkholat 2003). Some authors (Kamelin 1987, 2005, Krestov 2003, Belikovich & Galanin 2006, Krestov et al. 2010, Namzalov 2012, Kholoboyeva et al. 2015) consider that *Ulmus* and *Armeniaca* shrubberies are relic thermophilous communities related to temperate broad-leaved forests existed in Dauria during warmer Pliocene period.

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