A phytosociological survey of two lowland Caspian (Hyrcanian) remnant forests, Northern Iran, for validation of some forest syntaxa

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Abstract. Semeskandeh and Dasht-e Naz, two lowland wildlife refuges for threatened Hyrcanian forests were selected for a pilot phytosociological investigation. Forty relevés from these conservationally important lowland remnant forests have been classified by the modified TWINSPAN and synsystematically treated following the Braun-Blanquet approach. Two associations, *Zelkovo carpinifoliae-Quercetum castaneifoliae* and *Smilaco excelsae-Buxetum hyrcanae* were described. A comprehensive comparison between all described upper syntaxa within the lowland Hyrcanian forests and other related forests were provided, together with standard typifications. Since the studied lowland patches are among the last representatives of Hyrcanian lowland vegetation, the associations described here should expand the knowledge on diversity and structure of plant communities and their dynamic situation in space and time and can be further utilized for management and ecological modelling of such endangered forests.

Key words: classification, community, DCA, Hyrcanian, Iran, lowlands, phytosociology, TWINSPAN

Introduction

Hyrcanian (South Caspian) area is a unique closed canopy of mesic deciduous forests in North Iran, in contrast to the arid and semi-arid steppe landscapes characterizing most of the country. It extends from the Talish region in SE of the Republic of Azerbaijan to Golestan Province in NE Iran, with an area of approximately 50 000 km^2. That area is considered a remarkable refuge for a number of Tertiary relicts during the Quaternary period (Bobeck 1951; Zohary 1973; Denk & al. 2001; Atamov & al. 2006; Rouhi-Moghaddam & al. 2008; Hamzeh'ee & al. 2008; Akhani & al. 2010).

Among the three altitudinal belts recognized across the Hyrcanian forests, i.e. lowland, submontane and montane forests (e.g. Zohary 1973; Frey & Probst 1986; Naqinezhad & al. 2008; Hamzeh'ee & al. 2008; Siadati & al. 2010), lowland forests are considered a priority for vegetation and ecological investigation, due to their threatened status and habitat losses (Tregubov & Mobayen 1970; Zohary 1973; Frey & Probst 1986). In spite of intensive land degradation, the lowland zone still contains few isolated fragments of formerly more widespread lowland communities, dominated or subdominated by stands of *Alnus*, *Fraxinus*, *Quercus*, *Buxus*, etc.

(e.g. Tregubov & Mobayen 1970; Tabari & al. 2002; Hamzeh'ee & al. 2008).

Despite the long history of botanical and ecological researches into the Hyrcanian forests (e.g. Djazirei 1964, 1965; Tregubov 1967; Tregubov & Mobayen 1970; Zohary 1973; Dorostkar 1974; Dorostkar & Noirfalise 1976; Assadollahi 1980; Mossadegh 1981; Assadollahi & al. 1982; Hamzeh'ee 1994; Akhani 1998; Zarre & al. 1998; Klein 2001; Tabari & al. 2002; Akhani & Ziegler 2002; Nazarian & al. 2004; Ghahreman & al. 2006; Jafari & Akhani 2008; Ramezani & al. 2008; Siadati & al. 2010; Akhani & al. 2010), comprehensive vegetation data analysis is still lacking, particularly in the lowland areas. Studies intensively concentrated on the lowlands have been carried out by Rastin (1980, 1983), Tabari & al. (2002), Hamzeh'ee & al. (2008), and Naqinezhad & al. (2008).

There are two ambiguous issues relating to the phytosociological studies in the Hyrcanian forests, especially in the lowlands: (1) the comprehensive syntaxonomical scheme of all Hyrcanian forests is not clearly understood and thus determination of the related characteristic species is occasionally problematic; (2) the forest floristic elements are mostly affected by anthropogenic impact and, hence, natural distribution of the plant communities as well as their related characteristic species have been continuously changing in time.

This paper aims at: (1) presenting a syntaxonomical scheme for two remarkable remnants of the threatened Hyrcanian lowland forests, and connecting these data to all other available syntaxonomical information about the Hyrcanian area and similar places; (2) validating the defined associations on the basis of the latest modified phytosociological nomenclatural code (Weber & al. 2000).

Material and methods

Study area

The study area includes two protected lowland forests (Semeskandeh and Dasht-e Naz) in Mazandaran Province, N. Iran (Fig. 1). Both places are protected as wildlife refuges, according to the conservation rating of the Iranian Department of Environment (DOE) during the last 40 years. Semeskandeh is located 5 km SE of Sari, south of the Sari – Neka road, between 4045190 and 4049021 N and 689490 and 695375 E (UTM system; zone number: 39). The total surface of the forest area is 1041 ha and altitude ranges between 50 m and 190 m a.s.l. Dasht-e Naz is located in NE Sari, 25 km from the Gaharbaran-Sari road, between 4061966 and 4063849 N and 695081 and 696528 E (UTM system; zone number: 39). The total surface and the average altitude of the area is 56 ha and 5 m a.s.l., respectively.

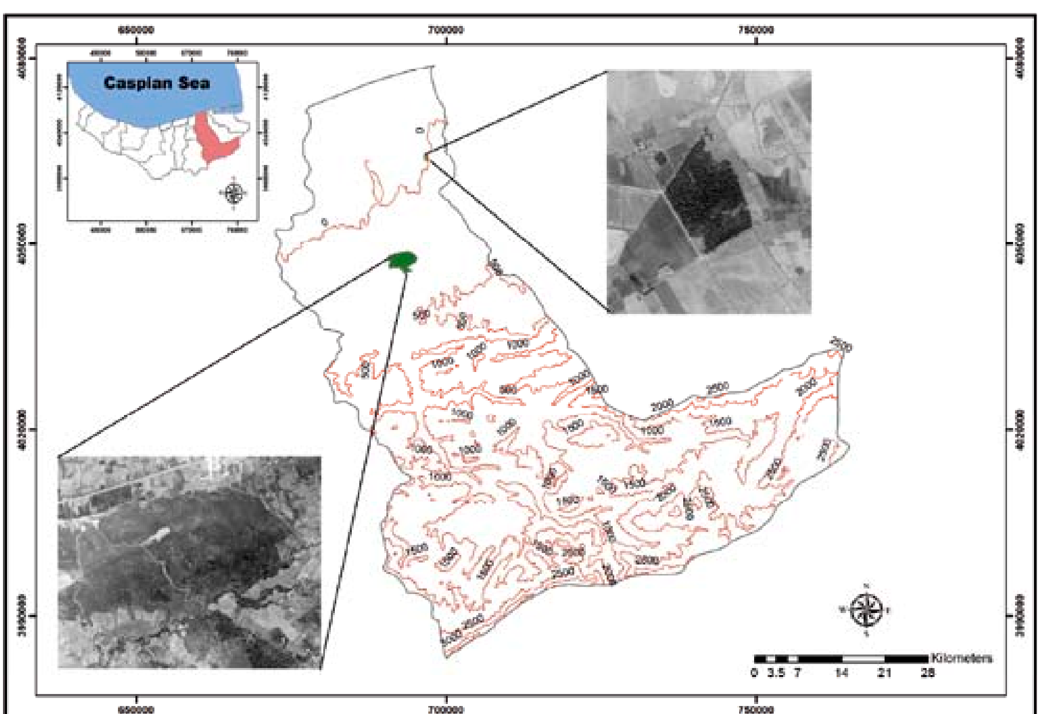

Fig. 1. Location of the studied lowland forests in the Hyrcanian area (N. Iran). Longitudes and latitudes of the map are based on the UTM system (zone number: 39).

Geology, soil and climate

Quaternary and Pleistocene alluvial and fluvial deposits are the main geological features of the studied area. Most parts of the Semeskandeh area belong to a Pleistocene alluvial plain, with considerable amount of Pleistocene loess deposits in northern and middle parts and Quaternary coarse and fine-grained deposits of the currently active streams in southern and western parts. No detailed geological map is available for Dasht-e Naz but the main geological features are very similar to Semeskandeh (Department of Environment of Mazandaran, unpublished data). Unfortunately, no soil information is available for the studied area, but the results of soil profile analysis in the adjoining areas to the Semeskandeh forest show that pH ranges from 6.2 to 7.9 and electrical conductivity ranges from 0.14 to 1.18 Ds. Also, different soil textures were observed in the area, i.e. clay, silty clay, silty clay loam, silty loam, clay loam (Natural Resource Department, Mazandaran, unpublished data of the Zarrinabad Forestry).

According to the ten-year data of the Dasht-e Naz Climate Station, the average annual precipitation is 660.4 mm. Mean monthly temperature is 17.6 °C. Mean maximum temperature in the hottest month and mean lowest temperature in the coldest month is 22.2 °C and 13 °C, respectively. The climate of the area is estimated as Mediterranean pluviseasonal-oceanic, according to a recent bioclimatic classification of Iran (Djamali & al. 2011).

Data collection and analysis

The phytosociological data were collected during 2009–2010, following the Braun-Blanquet approach (Braun-Blanquet 1964; Mueller-Dombois & Ellenberg 1974) and using the cover-abundance scales (r, +, 1…5). All forest formations with floristically and environmentally homogeneous composition were sampled. At first, whole forests were regularly stratified and then relevés of 100 m^2 were randomly allocated within each predefined formation. A divisive classification of 40 relevés was carried out, using the modified TWINSPAN method (Hill 1979; Roleček & al. 2009) embedded in a JUICE program (Tichý 2002). Pseudospecies cut levels were set to seven and the values of cut levels to 1, 2, 3, 4, 5, 6, 7. Five relevés were selected as a minimum group size for division. The fidelity of species to clusters and diagnostic species for particular vegetation units was calculated with the help of presence/absence data, using the phi-coefficient applied to clusters of equalized size (Chytrý & al. 2002, Tichý & Chytrý 2006). Only species with significant concentration in particular vegetation units (using Fisher's exact test and significance level $P<0.05$) and phi coefficient were considered. For the purpose of this work, a species was considered as diagnostic if $phi \geq 0.30$ and $P < 0.05$. A threshold value of $phi = 0.3$ was selected because it yields neither too long, nor too short lists of diagnostic species for each cluster (Illyés & al. 2007). The classification results were summarized (Table 1). A Detrended Correspondence Analysis (DCA) was also utilized to show the relationships between the vegetation groups recognized by the classification methods (Lepš & Šmilauer 2003).

To find the relationships of the clusters with forest vegetation elsewhere and to determine the best diagnostic species for the clusters, a large number of literature sources (*e.g.* Guinochet & Vilmorin 1973; Oberdorfer 1979; Ellenberg 1988) as well as many related books and papers were consulted. The names of syntaxa correspond to the code of phytosociological nomenclature (Weber & al. 2000). The bryophyte flora of studied associations has not been considered at this stage of research because of identification difficulties. Rechinger (1963–2005) for spermatophytes and Wendelbo (1976) and Khoshravesh & al. (2009) for pteridophytes were used as nomenclatural sources.

Results

Using modified TWINSPAN analysis, two main groups of relevés were classified at the first level of the analysis (Table 1, 2). Likewise, two clusters of relevés were also identified arranged along two axes of DCA ordination (Fig. 2). DCA eigenvalues for the first four axes were 0.66, 0.23, 0.19, and 0.16, respectively. The longest gradient was 4.1 SD. The first two axes explained 17.2 % of the total species inertia. Group **1**, the larger group, was characterized with *Quercus castaneifolia*, *Zelkova carpinifolia* and *Parrotia persica* as dominant species. Group **2** (with *Buxus hyrcana* and *Galanthus transcaucasicus* as dominant species) had a distinctive floristic composition and grew in wet humid valleys of the studied forests. It was thoroughly separated on the first axis of DCA analysis.

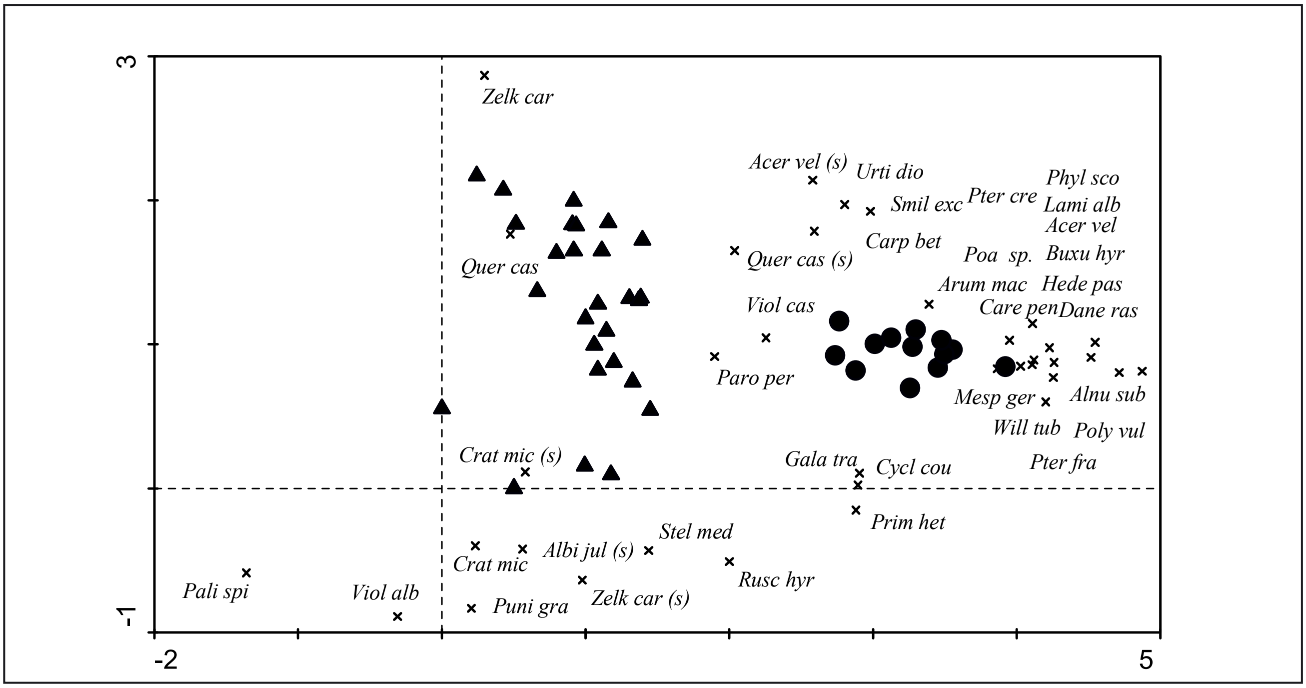

Fig. 2. DCA biplot of species (× marks) and relevés (▲, ●) in the studied areas. Species weight (1 %) was used for selection of species in the plot. ▲: *Zelkovo carpinifoliae-Quercetum castaneifoliae*, ●: *Smilaco excelsae-Buxetum hyrcanae*. The species included in the diagram abbreviated to the first four letters of the genus and the first three letters of the specific epithet are as follows: *Acer velotinum, Albizia julibrissin, Alnus subcordata, Arum maculatum, Brachypodium sylvaticum, Buxus hyrcana, Carex pendula, Carpinus betulus, Crataegus microphylla, Cyclamen coum, Danae racemosa, Galanthus transcaucasicus, Hedera pastuchovii, Lamium album, Paliurus spina-christi, Parrotia persica, Phyllitis scolopendrium, Poa sp., Polypodium vulgare, Primula heterochroma, Pteris cretica, Pterocarya fraxinifolia, Punica granatum, Quercus castaneifolia, Ruscus hyrcanus, Smilax excelsa, Stellaria media, Urtica dioica, Viola alba, Viola caspia, Willemetia tuberose, Zelkova carpinifolia.* **s** = seedling.

1. *Zelkovo carpinifoliae-Quercetum castaneifoliae* Tregubov & Mobayen ex Naqinezhad

nomenclatural typus: Table 1, rel. 22
= *Zelkovo-Quercetum* Tregubov & Mobayen (1970) (invalid name).

Most parts of the studied area were covered by this association. The groundwater table was well below the surface and even during rainy seasons flooding was rare and the soil is well drained. The habitat was more or less flat (0–15°) and relatively humid, with large masses of litter. The association was altitudinally ranged from 4 m to 190 m a.s.l. (see Table 1). It was also very shady, due to the intricate branching of co-dominant *Parrotia persica* crowns and respectively poor herbal underfloor. Forty plant species altogether were found in the community (see Tables 1 and 2). However, the moss cover was low and very sparse. The most important diagnostic species of this association was *Zelkova carpinifolia*. *Qurecus castaneifolia* was another thermophilous relict species, which was dominant and diagnostic in this association.

2. *Smilaco excelsae-Buxetum hyrcanae* Assadollahi ex Naqinezhad

nomenclatural typus: Table 1, rel. 37
= *Scolopendrio-Buxetum sempervirentis* Djazirei (1964); *Smilaci excelsae-Buxetum sempervirentis* (*sensu* Assadollahi (1980) (incorrect and invalid name).

This community developed on relatively wet areas along the main stream of Semeskandeh and was characterized with occurrence of large pure forest stands dominated by *Buxus hyrcana*. The moss cover in the community was very sparse. Judging by the geological map of the area, the substratum of that association was obviously different from the rest of the forest and was composed of recent fluvial sediments. The association was located on generally flat substratum and ranged altitudinally from 110 m to 131 m a.s.l. (see Table 1). There were 38 plant species in the community (see Tables 1 and 2).

The dominant and diagnostic species of that community was *Buxus hyrcana*, an endemic Hyrcanian shrub. *Smilax excelsa* was another diagnostic liana species of the association. Other herbal diagnostic species of the community were *Galanthus transcaucasicus*, *Cyclamen coum, Arum maculatum,* and *Viola caspia.*

Table 1. Structure of the Hyrcanian lowland forests [1 = *Zelkovo carpinifoliae-Quercetum castaneifoliae*. Typus relevé: 22. Semeskandeh, 4047673N, 695340E (UTM system; Zone number: 39); 2 = *Smilaco excelsae-Buxetum hyrcanae*. Typus relevé 37: Semeskandeh, 4046058 N, 693866 E (UTM system)]. Data for inclination in this table: 0 = no inclination, 1 = lower than 5°, 2 = 5–10°, 3 = 10–15°. Data for exposition are: 1 = N, 2 = W, 3 = E, 4 = S, 5 = NW, 6 = NE, 7 = SW, 8 = SE. L = Layers: 1: tree layer (high), 2: tree layer (middle), 3: tree layer (low), 4: shrub layer (high), 5: shrub layer (low), 6: herb layer (high), 7: juveniles, 8: seedlings.

Association	LAYER	1																											2												
Relevé number		01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Altitude (m a.s.l.)		180	177	170	004	098	160	153	144	069	099	063	088	186	160	137	166	160	170	140	160	155	159	051	136	190	124	096	130	113	129	124	120	122	127	113	110	119	128	131	120
Relevé surface (m^2)		100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Tree cover (%)		090	070	020	100	090	100	120	140	180	080	125	120	120	170	130	110	100	150	110	100	130	120	100	100	095	100	140	080	100	080	080	100	100	100	080	100	080	080	080	100
Shrub cover (%)		030	045	080	000	025	005	000	005	000	000	000	020	010	005	025	000	005	005	005	020	000	010	000	005	020	000	000	090	100	070	070	080	050	160	000	050	080	040	070	000
Herb cover (%)		100	030	020	030	020	010	030	080	070	010	020	020	060	100	035	025	010	080	070	050	075	000	005	040	030	030	035	100	020	020	010	010	010	020	010	020	010	010	005	040
Exposition		6	1	4		1	8	5	5	1	2	2	7	6	8	3	5	5	5	1	2	4	8	1	5	8	5	1	1	2	1										
Inclination (°)		2	2	2	0	3	2	2	1	1	2	2	2	2	2	1	3	2	1	1	3	1	2	3	1	1	2	3	1	1	1	0	0	0	0	0	0	0	0	0	0
Diagnostic species of the associations																																									
Quercus castaneifolia	1	5	5	2	3	5	.	3	5	5	.	3	5	5	5	4	5	5	5	5	5	5	5	4	5	5	5	5	.	.	.	.	.	.	2	.	.	.	.	.	.
Quercus castaneifolia	8	.	.	.	.	.	1	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	r	.	.	.	.	.	.	.	.	.	.
Crataegus microphylla	4	3	4	4	.	3	2	.	1	.	.	.	2	1	1	3	.	1	1	1	2	.	1	.	+	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Crataegus microphylla	8	.	.	.	+	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.
Zelkova carpinifolia	1	.	.	2	.	3	.	4	.	2	4	4	1	.	.	.	2	2	2	.	.	2	5	5	2	.	2	.	.	2	.	.	.	.	.	.	.	.	.	.	.
Zelkova carpinifolia	8	.	.	.	1	.	1	.	.	.	.	.	.	.	.	+	.	.	.	r	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Table 1. Continuation.

Buxus hyrcana	5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	5	5	4	4	4	3	4	5	3	4	3	4	.
Galanthus transcaucasicus	6	+	.	.	1	.	.	.	.	.	.	r	1	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	1	1	1	1	1	1	1	+	+	1	+	+	3
Cyclamen coum	6	+	.	.	+	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	1	1	1	1	+	1	2	+	+	.	1	+	1
Arum maculatum	6	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	r	1	+	+	+	.	.	+	r	.	1	.	2
Viola caspia	6	.	.	1	.	+	.	.	+	.	.	.	.	1	.	+	.	+	.	.	.	.	.	.	.	+	.	.	.	+	+	+	+	+	+	+	+	+	+	.	.
Smilax excelsa	5	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	.	+	+	+	.	.
Characteristic species of *Parrotio-Carpinion* Djazirei 1964																																									
Parrotia persica	3	2	.	.	5	2	5	4	3	3	3	.	2	3	4	4	.	.	5	3	1	2	2	.	3	5	3	4	2	4	5	3	3	4	4	1	3	2	3	3	4
Parrotia persica	8	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Albizia julibrissin	8	1	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Characteristic species of *Alnetalia subcordatae* Djazirei 1965 and subunits																																									
Pterocarya fraxinifolia	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	2	4	.	3	1	1	.	3	.	4
Acer velotinum	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	.	.	.	1	.	3	.	3	.
Acer velotinum	8	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	+	+	.	.	.	.	.	.	r	.	.	.	.
Alnus subcordata	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	.	.	.	2	.	.	2	.	.
Rumex sanguineus	6	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	1	.	.
Diospyrus lotus	3	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Diospyrus lotus	8	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sambucus ebulus	6	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Characteristic species of *Rhododendro-Fagetalia orientalis* Quezel & al. 1980, *Ilico-Fagetalia orientalis* Assadollahi 1980 & *Rubo-Fagion* Assadollahi 1980																																									
Ruscus hyrcanus	5	4	2	.	.	.	.	.	.	.	.	.	.	+	.	1	.	.	1	.	1	.	.	.	.	.	.	.	1	.	1	+	.	1	1	.	1	1	1	1	.
Carpinus betulus	2	.	.	.	.	.	.	2	2	4	.	.	.	.	2	2	.	.	.	3	2	.	.	3	.	.	1	.	5	.	.	4	3	4	4	.	4	4	3	3	.
Primula heterochroma	6	.	r	.	.	.	.	.	.	.	.	.	.	r	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	+	+	+	+	.	r
Hedera pastuchovii	4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4	+	r	1	.	.	1	1	1	2	+	+	1
Phyllitis scolopendrium	6	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	1	.	.	1	+	r	.	1	1	r
Danae rasemosa	5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	.	.	.	.	1	1	2	.	.	.
Pteris cretica	6	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	1	+	+	1	.	.
Mespilus germanica	5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	1	.
Oplismenus undulatifolius	6	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	+	.	.
Rubus hyrcanus	5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.
Polystichum aculeatum	6	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Characteristic species of *Querco-Fagea* Fukarek & Fabijanik 1968 & *Querco-Fagetea* Br.-Bl. & Vlieg. in Vlieg. 1937 em. Klika 1939																																									
Asplenium adiantum-nigrum	6	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.
Viola alba	6	1	2	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Table 1. Continuation.

Brachypodium sylvaticum	6	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Geum urbanum	6	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.
Ulmus minor	4	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Poa nemoralis	6	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Companions & others																																									
Polypodium vulgare	6	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	1	1	1	1	1	1	1
Stellaria media	6	+	+	r	1	.	.	.	.	.	1	.	.	+	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	+	+	.	.	.	.	1	.	.
Lamium album	6	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	+	.	.	.	1	.	.
Urtica dioica	6	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	+	r	.	.	.	+	.	.	.	.
Hypericum androsaemum	5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.
Carex pendula	6	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	1	+	+	1	+	1	+	1	1	.
Poa sp.	6	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	1	r	.	+	1	+	1
Willemtia tuberose	6	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	+	+	+
Equisetum telmateia	6	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.
Adiantum capillus-veneris	6	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.
Orobanche sp.	6	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r
Lonicera sp.	7	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.
Prunella vulgaris	6	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.
Carex divulsa	6	.	.	+	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Punica granatum	5	2	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sonchus oleraceus	6	.	r	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Carex sylvatica	6	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Prenanthes cacaliifolia	6	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Rubus caesius	5	.	.	.	+	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Chelidonium majus	6	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Paliurus spina-christi	4	.	.	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Artemisia annua	6	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Trifolium sp.	6	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cirsium vulgare	6	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Convolvulus arvensis	6	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cynoglossum officinale	6	.	r	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Centaurea hyrcanica	6	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Melica uniflora	6	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Moehringia trinervia	6	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Polypogon monspeliensis	6	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Table 2. Combined frequency table of two studied associations with percentage constancies, 1: *Zelkovo carpinifoliae-Quercetum castaneifoliae*, 2: *Smilaco excelsae-Buxetum hyrcanae*, as compared with related communities with categorical constancies, 3: Part of *Zelkovo-Carpinetum* by Dorostkar & Noirfalise 1976, Table 3, p. 46, 4: *Smilaci excelsae-Buxetum* by Assadollahi 1980 table 7, p.51. The upper indices are the phi coefficients (× 100).

Associations	1	2	3	4
Number of relevés	**27**	**13**	**5**	**13**
Diagnostic species of the associations				
Quercus castaneifolia	100 $^{84.9}$	23	V	V
Crataegus microphylla	78 $^{67.8}$	.	.	.
Zelkova carpinifolia	87 $^{51.5}$	8	.	IV
Buxus hyrcana	.	92 $^{92.6}$	V	.
Galanthus transcaucasicus	19	100 $^{82.9}$	.	.
Cyclamen coum	15	92 $^{77.7}$	.	.
Arum maculatum	7	69 $^{63.6}$	.	.
Viola caspia	26	77 $^{51.0}$	.	.
Smilax excelsa	4	38 $^{42.6}$	V	.
Characteristic species of *Parrotio-Carpinion* Djazirei 1964				
Parrotia persica	82	100	V	V
Albizia julibrissin	11	.	.	.
Characteristic species of *Alnetalia subcordatae* Djazirei 1965 and subunits				
Acer velutinum	4	54 $^{42.6}$	IV	II
Alnus subcordata	.	23 $^{36.1}$	IV	.
Diospyrus lotus	8	.	IV	II
Rumex sanguineus	.	15	.	.
Pterocarya fraxinifolia	.	69 $^{72.8}$	.	.
Sambucus ebulus	4	.	.	.
Characteristic species of *Rhododendro-Fagetalia orientalis* Quezel & al. 1980, *Ilico-Fagetalia orientalis* Assadollahi 1980 & *Rubo-Fagion* Assadollahi 1980				
Ruscus hyrcanus	22	69 $^{47.2}$	.	II
Carpinus betulus	33	69 $^{35.9}$	V	V
Primula heterochroma	11	46 $^{38.8}$	II	IV
Hedera pastuchovii	.	85 $^{85.6}$	V	II
Phyllitis scolopendrium	.	62 $^{66.7}$	.	.
Danae racemosa	.	38 $^{48.8}$	.	II
Pteris cretica	.	38 $^{48.8}$	V	.
Mespilus germanica	.	15	.	II
Rubus hyrcanus	.	8	.	.
Polystichum aculeatum	.	4	.	.
Oplismenus undulatifolius	.	.	III	III
Tilia platyphyllos	.	.	II	II
Prunus laurocerasus	.	.	V	.
Solanum kieseritzkii	.	.	IV	.
Scutellaria tournefortii	.	.	.	II
Colutea persica	.	.	.	I
Festuca drymeja	.	.	.	II
Vicia crocea	.	.	.	II
Acer cappadocicum subsp. *cappadocicum*	.	.	.	IV
Crataegus ambigua	.	.	.	I
Poa masenderana	.	.	.	IV
Characteristic species of *Querco-Fagea* Fukarek & Fabijanik 1968 & *Querco-Fagetea* Br.-Bl. & Vlieg. in Vlieg. 1937 em. Klika 1939				
Asplenium adiantum-nigrum	.	15	V	.
Viola alba	11	.	IV	.

Table 2. Continuation.

Geum urbanum	.	8	.	III
Poa nemoralis	4	.	.	II
Ulmus minor	4	.	.	.
Brachypodium sylvaticum	7	.	.	IV
Circaea lutetiana	.	.	III	II
Ulmus glabra	.	.	IV	II
Athyrium filix-femina	.	.	III	.
Carex digitata	.	.	III	.
Polystichum woronowii	.	.	II	.
Polystichum setiferum	.	.	II	.
Tamus communis	.	.	V	.
Viola odorata	.	.	.	V
Euphorbia amygdaloides	.	.	.	IV
Crataegus monogyna	.	.	.	III
Digitalis nervosa	.	.	.	II
Clinopodium umbrosum	.	.	.	II
Clinopodium vulgare	.	.	.	II
Galium odoratum	.	.	.	II
Sanicula europaea	.	.	.	II
Fragaria vesca	.	.	.	II
Companions & others				
Polypodium vulgare	4	$77^{74.6}$	IV	.
Hypericum androsaemum	4	8	.	III
Stellaria media	30	23	.	.
Lamium album	.	$31^{42.6}$	.	.
Urtica dioica	4	23	.	.
Carex pendula	.	$77^{79.1}$	.	.
Poa sp.	1	$62^{66.7}$	.	.
Willemetia tuberosa	.	$31^{42.6}$	.	.
Prunella vulgaris	.	8	.	I
Carex divulsa	7	.	.	V
Carex sylvatica	4	.	.	IV
Centaurea hyrcanica	4	.	.	II

Species with low frequency: *Equisetum telmateia* 2(8), *Adiantum capillus-veneris* 2(8), *Orobanche* sp. 2(8), *Lonicera* sp. 2(8), *Punica granatum* 1(11), *Sonchus oleraceus* 1(7), *Prenanthes cacaliifolia* 1(4), *Rubus caesius* 1(7), *Chelidonium majus* 1(7), *Paliurus spina-christi* 1(4), *Artemisia annua* 1(4), *Convolvulus arvensis* 1(4), *Cynoglossum officinale* 1(7), *Melica uniflora* 1(4), *Moehringia trinervia* 1(4), *Polypogon monspeliensis* 1(4), *Pteris dentata* 3(V), *Vincetoxicum nigrum* 4(II), *Rubus* sp. 4(II), *Dactylis glomerata* 4(II), *Lathyrus hirsutus* 4(II), *Bromus tomentellus* 4(II), *Toliris arvensis* subsp. *heterophylla* 4 (II), *Mentha* sp. 4 (I), *Astragalus glycyphyllos* 4(I), *Phyteuma spicatum* 4(I), *Oxalis corniculata* 4(I), *Buglossoides purpurocaerulea* 4(I), *Sorbus torminalis* 4(I), *Prunus avium* 4(I), *Fraxinus excelsior* 4(I), *Laserpitium latifolium* 4(I).

Discussion

Association *Zelkovo carpinifoliae-Quercetum castaneifoliae*

Although located in the lowland zone of the Hyrcanian forest, *Zelkovo carpinifoliae-Quercetum castaneifoliae* is ecologically different from some lowland vegetation (e.g. alderwood communities) with permanent soil wetness (Rastin 1983; Naqinezhad & al. 2008; Hamzeh'ee & al. 2008).

The most important diagnostic species of that community is *Zelkova carpinifolia*, a thermophilous arctotertiary relict species currently confined to Euxino-Hyrcanian forests (Zohary 1973; Browicz 1982; Zazanachvili 1999; Denk & al. 2001). This unique arboreal species is primarily a component of the lowland forests of the Caspian and the Black Sea, but it could also climb up to 1500 m a.s.l. in the Talish Mts (Republic of Azerbaijan) and in Iran, and even up to 1550 m a.s.l. in Turkey (Zohary 1973; Browicz 1982; Zazanachvili 1999; Akhani & al. 2010). In Turkey, it is less common and confined mainly to the NE parts, without any significant participation in the vegetation (Zohary 1973). Of the other diagnostic species of the community, *Qurecus castaneifolia* is an exclusively endemic oak species distributed across all Hyrcanian forests of Iran and Talish (Republic of Azerbaijan) (e.g. Zohary 1973; Browicz 1982; Atamov & al. 2006). It has played a very important role in the vegetation structure of the coastal plain of the Caspian Sea and the northern flanks and foothills of the Alborz Mts, up to 2400 m a.s.l. (Zohary 1973; Browicz 1982). The best conditions for its development though were between 200 m and 1200 m a.s.l. (Browicz 1982), with some specific forest communities, e.g. *Fraxino-Quercetum castaneifoliae* (Tabari & al. 2002), *Querco-Carpinetum* (Djazirei 1964 & 1965; Mossadegh 1981), *Acero-Quercetum castaneifoliae* (Dorostkar & Noirfalise 1976), *Querceto-Coryletum* (Teimoorzadeh & al. 2003), and *Querco-Buxetum* (e.g. Tregubov & Mobayen 1970). Another important co-dominant species in the community is *Parrotia persica.* Its natural range is limited to the Hyrcanian forests, up to the Talish Mts in the Republic of Azerbaijan in the west and NE Iran (Golestan Province) in the east, and one small, disjunct population in the forests southeast of the Great Caucasus (Safarov 1977; Browicz 1982; Sefidi & al. 2010). *Parrotia persica* grows mainly on low-lying plains and mountain foothills. The optimal conditions for its growth are between 250–400 m a.s.l. However, like the two above-mentioned species, it can be found also in some areas of the Hyrcanian forests, from the lowlands up to the mountain parts (up to 1400 m a.s.l.), with some specific communities, such as *Parrotio-Carpinetum* (Dorostkar & Noirfalise 1976; Djazirei 1964, 1965; Hejazi & Sabeti 1961; Mossadegh 1981). It also penetrates into the beech forests in some parts of the Hyrcanian forests (Assadi 1985).

Zelkovo carpinifoliae-Quercetum castaneifoliae was described here on the basis of a comparison of the diagnostic species of the community with all described syntaxa across the Hyrcanian area. This association was firstly considered a vicariant community for *Querco-Carpinetum* Djazirei (1964) in the drier climate and more xerophilous species of the eastern Hyrcanian forests (Treguvov & Mobayen 1970). However, the community was not published with appropriate diagnosis and phytosociological tables (see Tregubov & Mobayen (1970)). *Zelkovo-Quercetum* was then tabulated by Dorostkar (1974), Dorostkar & Noifalise (1976) and included within the larger community of *Zelkovo-Carpinetum* Dorostkar (1974). The latter community was described across a broad altitudinal range from lowlands to mountain areas, the lowland and foothill relevés of which were considered equivalent to *Zelkovo-Quercetum castaneifoliae*. That community was clearly not adopted either by Dorostkar & Noirfalise (1976), or by Assadollahi (1980).

The relevé data of Dorostkar & Noirfalise (1976) are incorporated in the current synoptic table (Table 2) for comparison with our study. They confirm the occurrence of a more or less similar floristic composition of the association between the two studies. In both studies, *Carpinus betulus* is less widespread in the lowlands and drastically increases in concentration and cover upwards towards the montane forests. *Zelkovo-Quercetum castaneifoliae,* with its specific characteristic species, was only found in the Hyrcanian area of Iran. There is no record of such association in the Talish (Azerbaijan Republic) and the Caucasus (Korotkov & al. 1991), nor in the Euxinian territory of Turkey (e.g. Quezel & al. 1980; Ketenoglu & al. 2010

There is no exact knowledge if or how *Zelkovo-Quercetum castaneifoliae* community has been modified in the studied lowland forests in time, but it is clear that *Quercus castaneifolia* stands used to be more abundant than now (e.g. Rouhi-Moghaddam & al. 2008). Because of intense felling, it has been replaced by other species, and particularly by the invasive *Parrotia persica* and *Carpinus betulus* (Tregubov & Mobayen 1970; Browicz 1982; Hamzeh'ee & al. 2008). Likewise, owing to exploitation, *Z. carpinifor-lia* is becoming ever scarcer and thus its felling is prohibited now in Iran (Browicz 1982). A recent study in terms of forest management has indicated that survival of *Quercus castaneifolia* within pure plantations was significantly lower than its survival in the mixed plantations with *Zelkova carpinifolia* (Rouhi-Moghaddam & al. 2008). This indicates that *Zelkovo-Quercetum castaneifoliae* is a well-established forest association across the Hyrcanian area.

Under Articles 2–9 of the International Code of Phytosociological Nomenclature (Weber & al. 2000), this community can be validated here with its correct name and nomenclature typus.

Association *Smilaco excelsae-Buxetum hyrcanae*

The habitat of *Smilaco excelsae-Buxetum hyrcanae* is very similar to the other lowland box communities (e.g. Hamzeh'ee & al. 2008), where *Buxus hyrcana* grows mainly along forest streams, brooks and rivers. The dominant and diagnostic species of this community is *Buxus hyrcana*, an endemic Hyrcanian shrub. The main habitat of *Buxus hyrcana* is the coastal plain, up to 200 m a.s.l. (Zohary 1973; Browicz 1986), where it penetrates into very moist, strongly shaded forests composed of some other arboreal species (Browicz 1986). *Buxus hyrcana* has been already considered as dominant and diagnostic species in many lowland communities, such as *Querco-Buxetum* Tregubov & Mobayen (1970), *Fraxino-Buxetum hyrcanae* (Tabari & al. 2002), *Pterido dentatae-Alnetum barbatae buxetosum hyrcanae* Hamzeh'ee & Naqinezhad (Hamzeh'ee & al. 2008), and *Celtiseto-Buxetum* (Zare & al. 1998). Furthermore, *Buxo-Fagetum* was also described in the upper mountain beech forests (Hamzeh'ee 1994). *Smilax excelsa* is a diagnostic liana of this association, distributed mainly in very humid lowland forests (e.g. Hamzeh'ee & al. 2008; Tabari & al. 2002). It was also considered as a characteristic species of the newly described alliance, *Smilaco excelsae-Alnion barbatae,* in the Hyrcanian lowland alderwoods (Hamzeh'ee & al. 2008).

Smilaco excelsae-Buxetum was firstly described by Assadollahi (1980) and Assadollahi & al. (1982). He believed that both *Querco-Buxetum*, a large lowland community (e.g. Tregubov 1967; Tregubov & Mobayen 1970; Mossadegh 1981), and *Scolopendrio-Buxetum* Djazirei (1964) should be given as synonyms under *Smilaco excelsae-Buxetum*. *Galanthus transcaucasicus* is one of the diagnostic herbal species of *Smilaco-Buxetum hyrcanae*. That species is restricted mainly to shady lowland and foothill forests (Wendelbo 1970; Mazhari 2004) and has not been reported yet in other communities within its distribution range in the Transcaucasus and Euxino-Hyrcanian areas. Only Selimov (2008) has reported a population of *Galanthus transcaucasicus* in *Parrotia persica* stands of the Talish region (Republic of Azerbaijan). *Pterocarya fraxinifolia* and *Alnus subcordata* (restricted to wet alluvial soils of the lowlands) are the characteristic species of *Alnion subcordatae* Djazirei (1965). They were frequently observed in *Smilaco excelsae-Buxetum*.

A comparison was made between our relevés and data provided by Assadollahi (1980) in a synoptic table (Table 2). The comparison indicates occurrence of a rather similar set of characteristic species between the two syntaxa. Since no nomenclatural typus was designated by Assadollahi (1980) for *Smilaco excelsae-Buxetum*, this community is validated here under Article 5 (Weber & al. 2000) and also corrected from "*Smilaci*" to "*Smilaco*".

A syntaxonomical overview of the Hyrcanian lowlands

Following the conventional classification methods, Zohary (1973) classified the Hyrcanian forests into three broad phytosociological classes, namely *Alnetea hyrcanicae, Zelkovo-Parrotietea* and *Fagetea orientalis*. This classification scheme has then been improved by Assadollahi (1980), Assadollahi & al. (1982) and Hamzeh'ee & al. (2008). Within *Querco-Fagetea* Br.-Bl. & Vlieg. in Vlieg. 1937 em. Klika 1939, two phytosociological orders have been identified in the Hyrcanian area, i.e. *Alnetalia subcordata* Djazirei (1965) (Hamzeh'ee & al. 2008) and *Rhododendro-Fagetalia orientalis* Quezel & al. (1980) including a Hyrcanian suborder *Ilico-Fagenetalia orientalis* Assadollahi (1980). From the latter suborder, two alliances were identified in the Hyrcanian area, namely *Parrotio-Carpinion* Djazirei (1965) and *Rubo-Fagion orientalis* Assadollahi (1980). Both *Zelkovo-Quercetum* and *Smilaco-Buxetum* consist of a number of common diagnostic species of *Parrotio-Carpinion* and, similarly to the earlier studies, can be syntaxonomically classified within this alliance (Dorostkar & Noirfalise 1976; Assadollahi 1980; Assadollahi & al. 1982). The most important common diagnostic species of this alliance and the current associations are *Quercus castaneifolia*, *Parrotia persica*, *Zelkova carpinifolia,* and *Albizia julibrisin.* Likewise, occurrence of a large number of characteristic species of *Rhododendro-Fagetalia orientalis* and *Querco-Fagetea* within these associations indicates the syntaxonomical affinities between them. *Parrotio-Carpinion* was reported first by Djazirei (1964) and then classified within *Zelkovo-Parrotietalia* by Djazirei (1965). That order was not accepted by Assadollahi (1980). Instead, he described a new suborder, *Ilico-Fagenetalia orientalis* Assadollahi (1980) (from *Rhododendro-Fagetalia* orientalis), for that alliance (see Table 2). On the other hand, occurrence of some characteristic members of *Alnetalia subcorda-*

tae and its subunits in the studied associations, and particularly in the *Smilaco excelsae-Buxetum* community, poses some difficulties for determining its syntaxonomical position. Although formerly classified in *Parrotio-Carpinion* (Assadollahi 1980), *Smilaco excelsae-Buxetum* shows certain similarities to *Alnion subcordatae* Djazirei (1965) and *Alnetalia subcordatae*, due to floristic composition and habitat features. Nevertheless, a comprehensive investigation of all described syntaxa in the Hyrcanian area will indicate the proper syntaxonomical classification of the *Buxus* communities.

Conservation remarks

Hyrcanian lowland forests are strongly threatened by habitat losses, owing to intensified mismanagement and urbanization. Knowledge of the biodiversity and ecology of these forests is required so as to define some scientifically-based policies for conservation and ecological repair. Many endemic plants from these forest patches are considered unique features of the global plant biodiversity and genetic fund. The associations described here would expand the knowledge on diversity and structure of plant communities and their dynamic situation in space and time. These lowland patches, along with some other areas (e.g. Hamzeh'ee & al. 2008) are the last representatives of the Hyrcanian lowland vegetation, one of the major plant refugia of the Northern Hemisphere. Both the Semeskandeh and Dahst-e Naz forests have been designated for several decades as a protected area. We expect that this paper will increase the awareness of conservational importance of these vulnerable communities, and that subsequently the data analyzed here will be used further for management and ecological modelling of such forests.

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