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Two new mesophilous oriental hornbeam communities from the northern Dinaric Alps (Bosnia and Herzegovina)

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Key words: *Carpinus orientalis*, *Carpinion orientalis*, *Ostryo-Tilion*, *Erythronio-Carpinion*, *Epimedio alpini-Carpinetum orientalis*, *Asplenio scolopendrii-Carpinetum orientalis*, phytosociology, syndynamics.

Ključne besede: *Carpinus orientalis*, *Carpinion orientalis*, *Ostryo-Tilion*, *Erythronio-Carpinion*, *Epimedio alpini-Carpinetum orientalis*, *Asplenio scolopendrii-Carpinetum orientalis*, fitocenologija, sindinamika.

Abstract

The paper describes two new mesophilous communities of oriental hornbeam (*Carpinus orientalis*) coppice from the northern Dinaric Alps in Bosnia and Herzegovina (B&H). While oriental hornbeam is mainly considered to be a part of thermophilous forests and scrub, numerical analysis of 103 relevés of *C. orientalis* dominated coppice from B&H has shown that two new, rather mesophilous, communities thrive on calcareous bedrock of NW B&H. They represent secondary successional stages of mesotermic forest vegetation in this region. Association *Epimedio alpini-Carpinetum orientalis* ass. nova hoc loco is related to Illyrian oak-hornbeam forests of *Erythronio-Carpinion betuli*, while *Asplenio scolopendrii-Carpinetum orientalis* ass. nova hoc loco is linked to Balkan submediterranean ravine forests of *Ostryo-Tilion*. Although these two associations were recorded only in the NW B&H, their distribution is potentially larger, as their source communities are relatively common throughout the Dinaric Alps, so the information about their distribution, vertical structure, and syndynamic relations could be very useful in a national scale forest management and nature conservation.

Izvleček

V članku opisujemo dve novi panjevski mezofilni združbi kraškega gabra (*Carpinus orientalis*) v severnem delu Dinarskega gorstva v Bosni in Hercegovini (B&H). Kraški gaber gradi predvsem termofilne gozdove in grmišča, vendar je numerična amaliza 103 popisov panjevcev s prevladujočim kraškim gabrom v B&H pokazala, da dve novi mezofilni združbi uspevata na apnenčasti podlagi v severozahodni B&H. Predstavljata faze v sekundarni sukcesiji mezotermne gozdne vegetacije v tem območju. Asociacija *Epimedio alpini-Carpinetum orientalis* ass. nova hoc loco je povezana z ilirskimi hrastovo-gabrovimi gozdovi zveze *Erythronio-Carpinion betuli*, asociacija *Asplenio scolopendrii-Carpinetum orientalis* ass. nova hoc loco pa z balkanskimi submediteranskimi gozdovi plemenitih listavcev zveze *Ostryo-Tilion*. Čeprav sta ti dve asociaciji zabeleženi samo v severozahodnem delu B&H je njihova potencialna razširjenost večja, saj so njihove izvorne združbe relativno pogoste v celotnem Dinarskem gorstvu. Zato je poznavanje njihove razširjenosti, vertikalne strukture in sindinamskih odnosov uporabno za gospodarjenje z gozdom in naravovarstvo na nacionalnem nivoju.

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Introduction

Oriental hornbeam (*Carpinus orientalis*) is a thermophilous and xerophilous tree species distributed in SE Europe (southern Italy and Balkan Peninsula) and extending to the Asia Minor, Syria, Caucasus region and Crimea (Sikkema & Caudullo 2016). Being typical element of Submediterranean forest vegetation, it can also be found on warmer sites of continental regions of its area of distribution. It is main species of canopy layer in Submediterranean thermophilous oriental-hornbeam forests of the Central and Southern Balkans (*Syringo-Carpinion orientalis*) (Mucina et al. 2016) and important understory species of many thermophilous deciduous oak-dominated forest communities of *Carpinion orientalis* and *Quercion frainetto* (Blasi et al. 2001, Vukelić 2012, Tomić & Rakonjac 2013, Stupar et al. 2016, Tzonev et al. 2019). The latter communities are often structurally degraded to *Carpinus orientalis* dominated coppice. Although floristically they can be very different, such degraded oriental hornbeam communities mainly have closed or semi-open canopy and, being mainly coppice, all of them share common prominent synmorphological characteristic, such as bushy appearance (related to the fact that after the cut back of the oriental hornbeam trees several shoots develop simultaneously from one stool).

Regardless of floristic differences, this physiognomical similarity led to poor recognition of new vegetation types within oriental hornbeam coppices in Western Balkans, as was already brought to attention by Šugar & Trinajstić (1988) who distinguished continental *C. orientalis* coppice in Croatia (*Cruciato glabrae-Carpinetum orientalis*) from Mediterranean *Querco-Carpinetum orientalis*. Majority of other continental *C. orientalis* coppices in the Western Balkans were treated in the scope of one widely comprehended association known under several invalid or illegitimate names (Stefanović 1989, Stupar et al. 2015). Moreover, until recently, there were only a few associations of *C. orientalis* dominated coppice recognized and correctly described in the whole Balkan Peninsula (Blečić & Lakušić 1967, Šugar & Trinajstić 1988, Bergmeier & Dimopoulos 2008, Tzonev 2013).

However, recent research suggests that there is a much higher diversity among these communities since they appear in different regions, reflect different ecological conditions, and are degradations of different types of oak forests (i.e., those of *Carpinion orientalis, Quercion confertae* or *Erythronio-Carpinion*) (Stupar et al. 2015, Miletić et al. 2016). While Stupar et al. (2015) encompassed all of the continental communities in Bosnia and Herzegovina (B&H) under the association *Cruciato glabrae-Carpinetum orientalis* Šugar et Trinajstić ex Stupar et al. 2015, they stated that this association is rather heterogeneous, with mesophilous species playing an important role in some stands in the NW B&H, and that further research is needed to reveal its diversity patterns. Additionally, they pointed out that in this transitional zone between Central and SE Europe, within the association of *Aceri obtusati-Quercetum petraeae* Stupar et al. 2015 one can find together two species of different ecologies, mesophilous *Carpinus betulus,* and xerothermophilous *Carpinus orientalis*. This suggested that there are possibly some more mesophilous communities where *C. orientalis* plays an important role in B&H.

The study aimed to use the results of the recent field research of *C. orientalis* coppice in B&H to describe two new mesophilous communities dominated by oriental hornbeam and characterize them by their ecology and floristic composition, which would in turn aid to the classification of this vegetation type in B&H, as well as in the wider context.

Methods and materials

Study area

The research took place in the middle part of the Vrbas River canyon with its surroundings. The area is situated in northwestern B&H and it is about a 40 km long geomorphological feature that predominantly has south-north direction in the northern part of the Dinaric Alps (Figure 1). Limestone canyons and gorges are intersected by a few rather small valleys in Bočac, Krupa na Vrbasu, Rekavice, and Karanovac and surrounded by predominantly limestone and dolomitic low mountains (up to 1330 m a.s.l.) and plateaus (400–600 m a.s.l) Čemernica, Tisovac, Osmača and Starčevica to the east and Manjača Mt. to the west (Mojićević et al. 1976, Marinković & Ahac 1979). Vrbas River elevations are between 160 m in the north and 270 m a.s.l. in the south. Climate is modified continental with the maritime influence from the west and Mediterranean from the south (Delijanić et al. 1964). The average annual temperature for Banja Luka is 11.0 °C and annual rainfall is 1024 mm (Anonymous n.d.). Biogeographically, this area lies at the border between two regions, i.e., Pre-Pannonian (continental, northern B&H) and Dinaric (mountainous, central B&H) (Stefanović et al. 1983). It is also an area that is under the strong anthropogenic influence for centuries, and large portions of land were either deforested or structurally degraded to coppice or shrub communities.

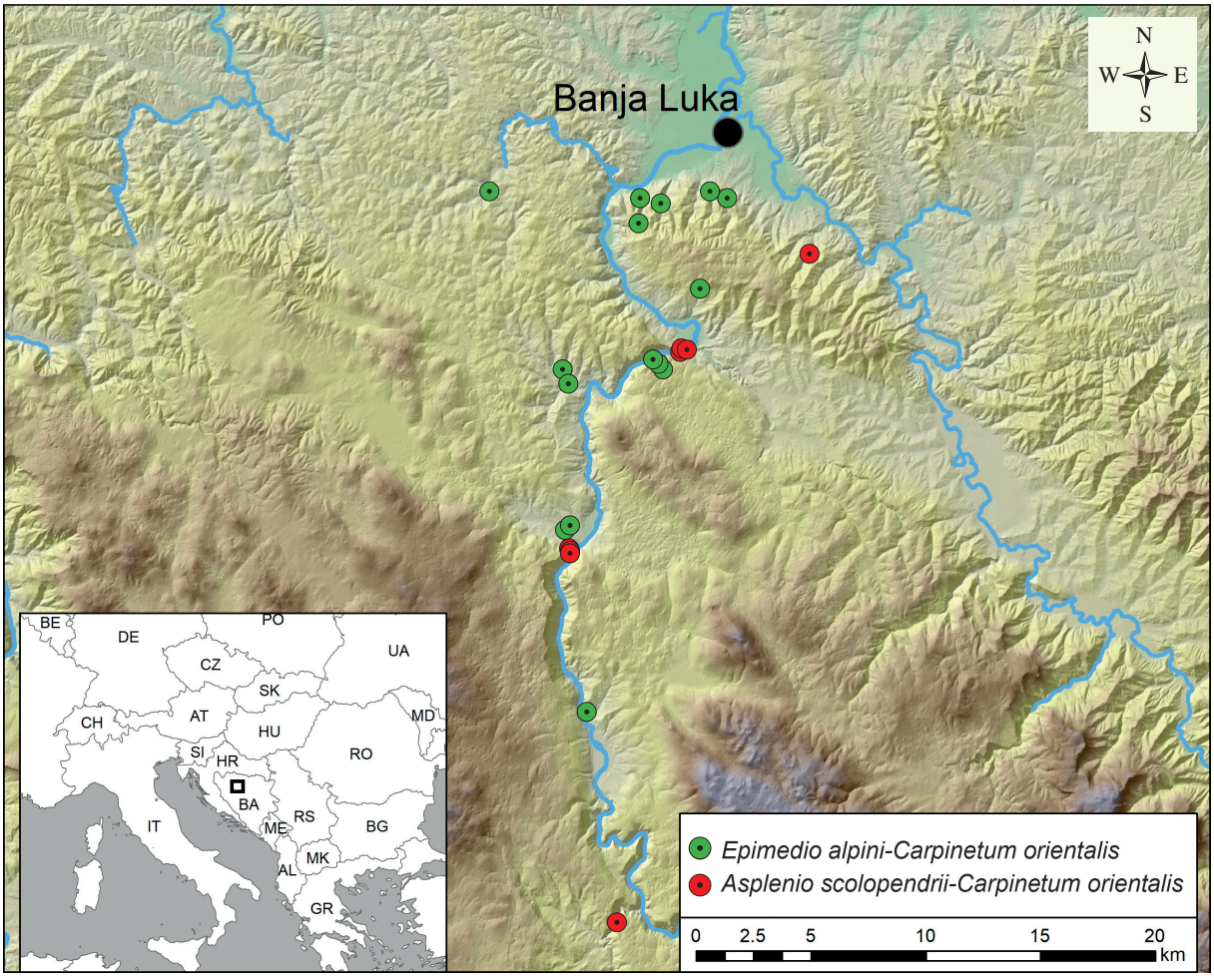

Figure 1: Locations of relevés.
Slika 1: Lokacije popisov.

Data collection and analysis

All 103 relevés used in this study are stored in, and available from, the Forests Vegetation Database of Bosnia and Herzegovina, with the ID EU-BA-001 in the Global Index of Vegetation-Plot Databases (Dengler et al. 2011). From the year of 1998, but mainly in the last ten years, we recorded 51 relevés of *C. orientalis* coppice in B&H using standard Central European phytosociological method (Braun-Blanquet 1964). Together with 52 relevés from literature (Fabijanić et al. 1963, Stefanović & Manuševa 1971, Kaćanski 1983, Stefanović 1989, Lakušić & Redžić 1991, Muratspahić et al. 1991, Bucalo 1999, Miletić et al. 2016) they were stored into the Turboveg database (Hennekens & Schaminée 2001) and then exported into JUICE software (Tichý 2002) for further analysis.

Before numerical analysis was applied, we excluded mosses from the dataset, as they were not recorded by all authors. For the means of numerical analysis, all layers were merged into a single layer to take account of inconsistent sampling in the relevés from literature, even though we recorded four layers during the field investigation (canopy layer: < 10 and > 5 m, understory layer: < 5 and > 1 m, shrub layer: < 1 m and herb layer). However, understory and shrub layers were combined into a single understory layer for use in the text and the preparation of the tables with relevés. Records of species determined to the genus level were deleted. Taxa occurring in three or fewer relevés were omitted from the analysis to reduce noise (Juvan et al. 2013, Stupar et al. 2015). *Quercus daleschampi* was treated as *Q. petraea*, while *Lathyrus vernus* and *L. venetus* were combined. Taxa from taxonomically critical groups were also combined (*Bromus erectus*, *Carex muricata*, *Cytisus hirsutus*, *Festuca pseudovina,* and *Taraxacum officinale*).

The numerical classification of the data set was performed in PC-ORD (McCune & Mefford 1999) using Flexible beta (-0.25) and Relative Sørensen. Considering that the study aimed to delineate and describe mesophytic oriental hornbeam communities outside of *Carpinion orientalis*, after cluster analysis, we selected the level of division (four groups of relevés) that best suited the aim. Diagnostic species for clusters were determined using species fidelity measure (Chytrý et al. 2002) in the JUICE software. We also calculated Fischer's exact test and gave a zero fidelity value to a species with P>0.001. The threshold phi value for the species to be considered as a diagnostic was set at 0.25.

All relevés, together with the unweighted species ecological indicator values (EIVs) for temperature, light, moisture, continentality, soil reaction and nutrients (Pignatti et al. 2005) were passively projected onto a non-metric multidimensional scaling (NMDS) plot to relieve main ecological factors that affect the variation of the floristic composition inside the data set. We used Bray-Curtis distance measure and square-root transformation of cover data. The significance of EIVs correlation with the NMDS relevé scores was tested using the modified permutation test proposed by Zelený & Schaffers (2012). The analysis was done in R software, version 3.4.1 (The R Foundation for Statistical Computing 2017) using the vegan package (https://github.com/vegandevs/vegan).

Plant nomenclature followed Euro+Med (2006). Syntaxonomical concepts and nomenclature of higher syntaxa followed Mucina et al. (2016). Descriptions of new syntaxa strictly followed the rules of ICPN (Theurillat et al. 2020).

Results

Numerical analysis of *Carpinus orientalis* dominated coppice from Bosnia and Herzegovina led to the delimitation of four ecologically and floristically distinct groups of clusters (Figure 2): xerophilous (clusters 1 and 2) and mesophilous (clusters 3 and 4). They are characterized by distinctive floristic composition with clearly defined diagnostic species (Table 1). This is also supported by the NDMS ordination plot, where the main ecological factors influencing the variation in the floristic composition are moisture and nutrients (positively correlated to the first axis) and light (negatively correlated to the first axis) (Figure 3). Xerophilous clusters (left side of the ordination and cluster diagrams) belong to already known associations, i.e., *Rusco aculeati-Carpinetum orientalis* Blečić et Lakušić 1967 (cluster 1) and *Cruciato glabrae-Carpinetum orientalis* Šugar et Trinajstić ex Stupar et al. 2015

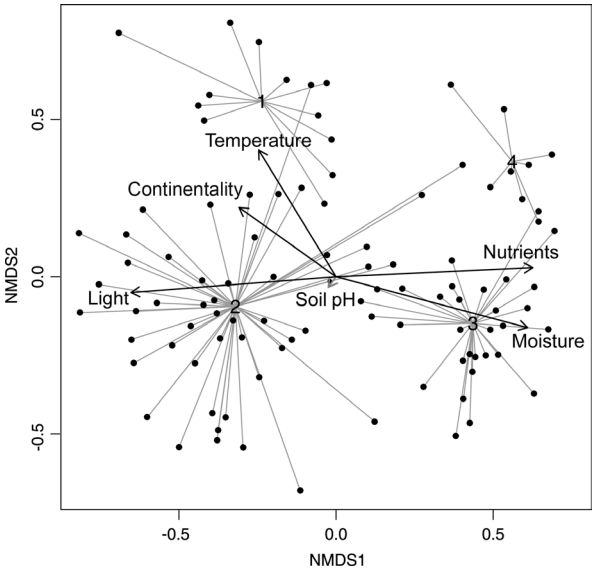

Figure 3: NDMS spider plot of 103 classified relevés of the *C. orientalis* coppice in B&H with EIVs passively projected. Centroids of clusters are indicated by numbers corresponding to Table 1, Figure 2, and to cluster numbers used in the text.
Slika 3: NDMS graf 103 klasificiranih popisov panjevcev kraškega gabra v B&H s pasivno projiciranimi EIV vrednostmi. Centroidi klastrov so predstavljeni s številkami, ki odgovarjajo klastrom v Tabeli 1, Sliki 2 in številkam klastrov v besedilu.

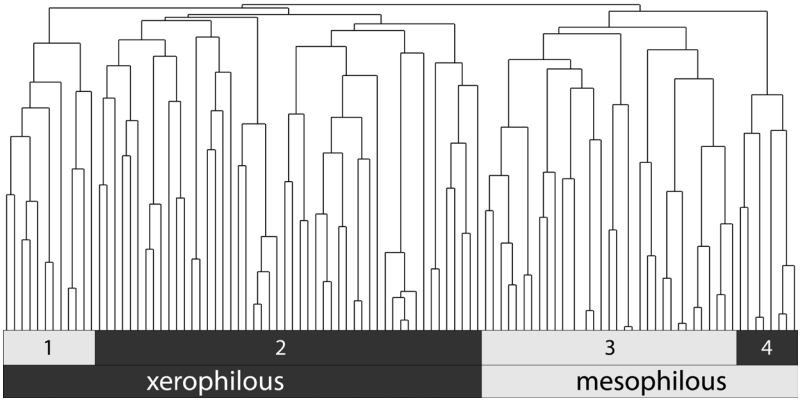

Figure 2: Classification of *C. orientalis* coppice in Bosnia and Herzegovina. Clusters:
1 – *Rusco aculeati-Carpinetum orientalis*,
2 – *Cruciato glabrae-Carpinetum orientalis*,
3 – *Epimedio alpini-Carpinetum orientalis*,
4 – *Asplenio scolopendrii-Carpinetum orientalis*.
Slika 2: Klasifikacija panjevcev kraškega gabra v Bosni in Hercegovini. Klastri:
1 – *Rusco aculeati-Carpinetum orientalis*,
2 – *Cruciato glabrae-Carpinetum orientalis*,
3 – *Epimedio alpini-Carpinetum orientalis*,
4 – *Asplenio scolopendrii-Carpinetum orientalis*.

(cluster 2), while mesophilous clusters 3 and 4 (right side of the ordination and cluster diagrams) are recognized as new associations.

These results suggest new syntaxonomical scheme of *Carpinus orientalis* coppice in B&H with four associations within three alliances and two classes:

Quercetea pubescentis Doing-Kraft ex Scamoni et Passarge 1959
Quercetalia pubescenti-petraeae Klika 1933
Carpinion orientalis Horvat 1958
Rusco aculeati-Carpinetum orientalis Blečić et Lakušić 1967
Cruciato glabrae-Carpinetum orientalis Šugar et Trinajstić ex Stupar et al. 2015
Carpino-Fagetea sylvaticae Jakucs ex Passarge 1968
Carpinetalia betuli P. Fukarek 1968
Erythronio-Carpinion (Horvat 1958) Marinček in Wallnöfer et al. 1993
Epimedio alpini-Carpinetum orientalis ass. nova hoc loco (Table 1 column 3, Table 2)
Aceretalia pseudoplatani Moor 1976 nom. conserv. propos.
Ostryo carpinifoliae-Tilion platyphylli (Košir et al. 2008) Čarni in Willner et al. 2016
Asplenio scolopendrii-Carpinetum orientalis ass. nova hoc loco (Table 1 column 4, Table 3)

Description of the new syntaxa

Epimedio alpini-Carpinetum orientalis ass. nova hoc loco (Table 1, column 3)

Typus: Table 2, rel. 11 – holotypus hoc loco

Stands of this association are coppices that represent secondary succession stages of the association *Aceri obtusati-Quercetum petraeae* Stupar et al. 2015. They are found in NW BIH (Figure 1), on mild to moderately steep mainly warmer slopes on calcareous substrates (limestone and dolomites) and elevations between 200 and 600 m a.s.l. Due to closed canopy, the stands are very shaded which results in the poorer species composition than the source association, however, the cover of the herb layer can sometimes be very high. These stands are coppices with a bushy appearance and height between 5 and 10 m (Figure 4). Due to mild terrain relief and closeness to settlements, these stands are continuously being coppiced and consequently maintained in the degraded stage.

The dominant species of the canopy layer is *Carpinus orientalis*, while other diagnostic species include species characteristic for oak-hornbeam forests (*Erythronio-Carpinion betuli*) such as *Carpinus betulus, Cyclamen purpurascens, Epimedium alpinum, Helleborus odorus, Potentilla micrantha, Primula acaulis, Ruscus hypoglossum, Tamus communis*, but also the other species of mesophilous deciduous forests

Figure 4: Stand of the association *Epimedio alpini-Carpinetum orientalis* in Starčevica (Drenovača). Photo: Vladimir Stupar.
Slika 4: Sestoj asociacije *Epimedio alpini-Carpinetum orientalis* pri Starčevici (Drenovača). Foto: Vladimir Stupar.

(*Fagetalia sylvaticae*): *Ajuga reptans, Aremonia agrimonoides, Asarum europaeum, Brachypodium sylvaticum, Carex pilosa, Cruciata glabra, Drymochloa drymeja, Geum urbanum, Glechoma hirsuta, Hedera helix, Melica uniflora, Polypodium vulgare, Pulmonaria officinalis, Sanicula europaea, Stellaria holostea, Symphytum tuberosum,* etc. *Fraxinus ornus* and *Acer obtusatum* are usually present in the canopy layer with lower cover values. There are only individual plants of *Quercus petraea* in the canopy and understory layers, but besides this general lack of *Q. petraea*, the main difference between this association and *Aceri obtusati-Quercetum petraeae* is lack or low cover and frequency of light-demanding species such as *Lathyrus niger, Melittis melissophyllum, Tanacetum corymbosum* and *Aegonychon purpurocaeruleum* in *Epimedio-Carpinetum orientalis,* all due to light shortage under the closed canopy of *C. orientalis* coppice. Also, the average number of species in *Epimedio-Carpinetum orientalis* is lower by ten when compared to *Aceri obtusati-Quercetum petraeae*. The stands of this association were formerly assigned to *Cruciato glabrae-Carpinetum orientalis* Šugar et Trinajstić ex Stupar et al. 2015 from which they are differentiated by many mesophilous species and lack of the thermophilous *Carpinion orientalis* species.

Asplenio scolopendrii-Carpinetum orientalis ass. nova hoc loco (Table 1 column 4)

Typus: Table 3, rel. 6 – holotypus hoc loco

This interesting association is found on "microlocalities" in canyons and gorges of the Vrbas River and its confluences (Figure 1). It is the secondary succession stage of the ravine forests of *Ostryo-Tilion*. They occupy northern, very steep (35–50°) and stony (50–80% of the bare rock) slopes on limestone, and the elevations between 200 and 400 m a.s.l. These are also coppices with a bushy appearance and height between 7 and 10 m (Figure 5). Although these sites are hardly accessible they are still being regularly coppiced and maintained in a structurally degraded state.

The main species of the canopy layer is *Carpinus orientalis*, with sometimes admixed tree species of the potential *Ostryo-Tilion* community: *Fraxinus ornus, Ostrya carpinifolia, Tilia tomentosa* and *Acer monspessulanum*. Besides oriental hornbeam, other character species are mesophilous ferns *Polystichum setiferum, Asplenium scolopendrium, Asplenium trichomanes,* and *Polypodium vulgare* along with *Saxifraga rotundifolia, Veratrum nigrum,*

Figure 5: Stand of the association *Asplenio scolopendrii-Carpinetum orientalis* in Vrbas River canyon. Photo: Ognjen Lukić.
Slika 5: Sestoj asociacije *Asplenio scolopendrii-Carpinetum orientalis* v kanjonu reke Vrbas. Foto: Ognjen Lukić.

Geranium robertianum, Carex digitata, and *Asplenium ceterach*. Among other species characteristic for ravine forests (*Ostryo-Tilion)* we can find *Hedera helix, Helleborus odorus, Hepatica nobilis, Cyclamen purpurascens,* etc. Species characteristic for *Carpino-Fagetea* are also frequent, while of the species characteristic for *Quercetea pubescentis* there are only *Cornus mas* and *Sesleria autumnalis* with higher frequency.

Discussion

Our results suggest that *Epimedio-Carpinetum orientalis* is a secondary succession stage of *Aceri obtusati-Quercetum petraeae*, which is also found over calcareous bedrock in the NW part of B&H. Although Stupar et al. (2015) treated *Aceri obtusati-Quercetum petraeae* as a part of thermophilous deciduous forests of *Quercetalia pubescentis* they did not assign it to any of the alliances in this order, and stated that this association represents the transition from thermophilous forests of *Carpinion orientalis* towards mesophilous forests of *Carpinion betuli* (i.e. *Erythronio-Carpinion*). Although its understory is made of thermophilous species of SE European (*Carpinus orientalis, Acer obtusatum,* and *Fraxinus ornus*), and also wider distribution (*Cornus mas, Euonymus verrucosus,* and *Sorbus torminalis*), there are also frequent mesophilous elements, such as *Carpinus betulus, Acer campestre* and *Prunus avium*. Moreover, the floristic composition of its herb layer is mainly mesophilous, with only several thermophilous species of SE European distribution. All of this is characteristic of *Erythronio-Carpinion* (Košir et al. 2013, Novák et al. 2020), which is probably where *Aceri obtusati-Quercetum petraeae* belongs. Although in theory degradation of *Aceri obtusati-Quercetum petraeae* should be more thermophilous, selective logging of oaks and regular coppicing of the oriental hornbeam resulted in the closed canopy and actually more mesophilous oriental hornbeam coppice of *Epimedio-Carpinetum orientalis*.

Although we recorded *Epimedio-Carpinetum orientalis* only in the NW B&H, there is a mention of oriental hornbeam coppice resulted from the degradation of oak-hornbeam forest (*Querco-Carpinetum illyricum typicum*) from Lepenica in the central B&H (Fabijanić et al. 1963). Although there are no relevés for this *C. orientalis* coppice, *Querco-Carpinetum illyricum typicum* is floristically very similar to *Aceri obtusati-Quercetum petraeae* (*Carpinus betulus* together with *C. orientalis* and other thermophilous species in the understory), so it could be expected that the distribution of both, *Aceri obtusati-Quercetum petraeae* and its degradation stage *Epimedio-Carpinetum orientalis* is potentially larger than recorded. It should also be pointed out that Fabijanić et al. (1963) argued that *Querco-Carpinetum illyricum typicum* is typical oak-hornbeam community (belonging to *Carpinion betuli illyrico-podolicum*) on calcareous bedrock in B&H stressing out that it is more thermophilous than originally described climax oak-hornbeam community of continental Croatia *Querco-Carpinetum croaticum* Horvat 1938 (i.e. *Epimedio-Carpinetum betuli*).

Although there is an evident floristic similarity between *Aceri obtusati-Quercetum petraeae* and its secondary successional stage *Epimedio-Carpinetum orientalis*, there are also clear differences, which reflect in different physiognomy of oriental hornbeam coppice, lack of edifier in the upper layer (*Quercus petraea*), and the smaller overall number of species per relevé. The latter is due to the closed canopy of oriental hornbeam coppice, which does not allow light to reach the herb layer. Albeit secondary succession stage, light shortage under the closed canopy together with continuous coppicing resulted in the formation of the relatively stable degradation stage which is hard to convert to high forests of *Aceri obtusati-Quercetum petraeae*. This led us to the conclusion that secondary succession stages of different oak–hornbeam forests, if they are stable, low and dark hornbeam and/or oriental hornbeam coppices, without upper tree layer, and with the low cover or without oaks, could be treated as separate associations (or at least subassociations) inside the same alliance as their source community. This would also relate better with typologies used in forest management.

However, there is an opinion that some pure oriental hornbeam communities should be classified in its own alliance, as is the case with the Submediterranean thermophilous oriental hornbeam forests of the Central and Southern Balkans of *Syringo-Carpinion* (Mucina et al. 2016). Their source communities with various oaks are instead being classified into the Amphiadriatic alliance of *Carpinion orientalis* (Tzonev et al. 2019) although they lack Illyrian species which are replaced with eastern-central Balkan ones. Following this logic, obviously mesophilous *Arabido turritae-Carpinetum orientalis* Tzonev 2013 (Tzonev 2013) is classified into *Syringo-Carpinion orientalis* (Tzonev et al. 2009), while floristically it belongs to *Erythronio-Carpinion*.

Asplenio scolopendrii-Carpinetum orientalis is a member of the Submediterranean ravine forests of *Ostryo-Tilion*. Although this alliance is very well characterized by its characteristic species combination it was recognized only recently as an independent syntaxon at the level of suballiance (Košir et al. 2008), and then later on raised at the level of alliance (Willner et al. 2016). Stefanović (1979)

wrote about *Aceri-Tilietum mixtum* in the canyons of the Dinaric Alps which fits perfectly into the circumscription of the *Ostryo-Tilion*, although it was not taken into consideration by Košir et al. (2008). *Asplenio-Carpinetum* is probably the secondary successional stage of this community, occurring on the higher parts of canyon slopes on colder exposures, whereas closer to the river and more humid lower parts are degraded to *Ostrya carpinifolia* ravine communities.

According to Stefanović (1979), *Aceri-Tilietum mixtum* with the higher cover of *Carpinus orientalis* is more common in Neretva and Morača River canyons (Herzegovina and Montenegro) so it can be expected that *Asplenio-Carpinetum* has a larger distribution in the canyons of Dinaric Alps.

Disturbance pattern, along with a high cover of bare rock doesn't allow this community to progress further towards the climax community of *Ostryo-Tilion*. However, it still has a huge protective role (antierosion) and presents one more authentic forest habitat of B&H canyons.

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Table 1: Frequency-fidelity table of *Carpinus orientalis* coppice communities in B&H (fidelity value in superscript multiplied by 100). Diagnostic species (phi values higher than 0.25) for each community are shaded (only species with the phi value higher than 0.4 are presented). Cluster numbers correspond to those used throughout the text.

Tabela 1: Tabela frekvenc in navezanosti panjevski združb vrste *Carpinus orientalis* v B&H (nadpisane vrednosti navezanosti vrst so pomnožene s 100). Diagnostične vrste (fi vrednosti večje od) vsake združbe so zasenčene (prikazane so samo vrste s fi vrednostjo, večjo od 0,4). Številke klastrov so enake kot v besedilu.

Group number	1	2	3	4
No. of relevés	12	50	33	8
Rusco aculeati-Carpinetum orientalis				
Paliurus spina-christi	$83^{87,4}$	2	.	.
Asparagus acutifolius	$58^{69,8}$	2	.	.
Rubus ulmifolius	$58^{68,1}$	4	.	.
Petteria ramentacea	$50^{63,5}$	2	.	.
Brachypodium pinnatum	$58^{63,3}$	10	.	.
Acer monspessulanum	100^{63}	14	6	62
Viola alba	$67^{61,8}$	10	12	.
Pistacia terebinthus	$42^{59,1}$	.	.	.
Clematis flammula	$42^{59,1}$	.	.	.
Satureja montana	$33^{49,8}$	2	.	.
Cruciato glabrae-Carpinetum orientalis				
Thymus pulegioides ssp. *montanus*	8	$76^{71,8}$	9	.
Euphorbia cyparissias	.	$62^{69,1}$	6	.
Origanum vulgare	.	$36^{54,5}$	.	.
Galium lucidum	8	$52^{52,8}$	9	.
Teucrium chamaedrys	75	$88^{52,4}$	9	.
Bromus erectus agg.	8	$48^{51,6}$	6	.
Dorycnium pentaphyllum ssp. *germanicum*	.	$30^{49,3}$	.	.
Stachys recta	.	$28^{47,5}$	.	.
Lotus corniculatus	8	$36^{45,8}$	.	.
Filipendula vulgaris	.	$30^{45,6}$	3	.
Sedum acre	.	$30^{45,6}$	3	.
Cytisus hirsutus	.	$38^{44,4}$	12	.
Pilosella officinarum	8	$34^{43,9}$	.	.
Juniperus communis	.	$48^{43,1}$	27	.
Scabiosa cinerea ssp. cinerea	.	$22^{41,8}$	.	.
Epimedio alpinum-Carpinetum orientalis				
Cruciata glabra	8	24	$85^{64,7}$	12
Quercus petraea	.	26	$67^{59,5}$	.
Rosa arvensis	.	34	$79^{59,1}$	12
Festuca heterophylla	17	8	$64^{57,9}$	.
Ajuga reptans	8	6	$55^{57,1}$	.
Cyclamen purpurascens	.	20	$85^{54,7}$	50
Acer obtusatum	8	44	$76^{54,1}$	.
Helleborus odorus	.	42	100^{53}	75
Carpinus betulus	.	12	$45^{51,2}$	.
Acer tataricum	.	6	39^{51}	.
Lathyrus vernus	.	4	$36^{50,4}$	.

Group number	1	2	3	4
No. of relevés	12	50	33	8
Luzula forsteri	.	.	$30^{49,6}$	.
Sorbus torminalis	8	20	$55^{48,2}$	.
Glechoma hirsuta	8	32	$79^{46,9}$	38
Drymochloa drymeja	.	.	$27^{46,9}$	.
Sanicula europaea	.	2	$27^{44,2}$	.
Stellaria holostea	.	6	$42^{43,7}$	12
Aremonia agrimonoides	.	12	$55^{43,5}$	25
Hedera helix	50	24	$94^{42,4}$	62
Brachypodium sylvaticum	25	14	$73^{42,3}$	38
Epimedium alpinum	.	2	36^{41}	12
Asplenio scolopendrium-Carpinetum orientalis				
Saxifraga rotundifolia	.	.	6	$100^{96,1}$
Veratrum nigrum	.	10	.	$100^{93,7}$
Polystichum setiferum	.	2	27	$100^{83,6}$
Asplenium scolopendrium	.	2	15	$88^{80,6}$
Carex digitata	.	10	36	100^{76}
Hepatica nobilis	.	8	33	$88^{68,3}$
Geranium robertianum	17	4	24	$88^{66,7}$
Valeriana officinalis	.	2	.	$50^{63,5}$
Asplenium trichomanes	25	22	39	$100^{61,8}$
Peltaria alliacea	.	4	15	$62^{60,3}$
Lamium galeobdolon	.	8	12	$62^{59,7}$
Mercurialis perennis	.	2	18	$62^{59,6}$
Sambucus nigra	.	.	.	$38^{55,7}$
Galium schultesii	.	.	12	$50^{54,9}$
Galium sylvaticum	.	.	12	$50^{54,9}$
Polypodium vulgare	.	2	$61^{27,5}$	$88^{59,6}$
Other species with high frequency				
Carpinus orientalis	100	100	100	100
Sesleria autumnalis	100	76	24	75
Crataegus monogyna	58	54	76	38
Fraxinus ornus	75	94	91	88
Cornus mas	25	60	79	100
Asplenium ceterach	50	30	30	88
Ruscus aculeatus	75	16	48	25

Table 2: *Epimedio alpini-Carpinetum orientalis* ass. nov. hoc loco, holotypus: relevé 11 (A – canopy layer (> 5 m), B – understory layer (< 5 m), C – herb layer).

Tabela 2: *Epimedio alpini-Carpinetum orientalis* ass. nov. hoc loco, holotip: popis 11 (A – drevesna plast (> 5 m), B – grmovna plast (< 5 m), C – zeliščna plast).

Relevé number		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Relevé area (m2)		100	100	100	225	400	400	400	400	400	400	400	400	400	400	225
Altitude (m)		340	390	477	310	370	340	308	543	552	523	230	323	258	270	280
Aspect		SE	SE	S	W	E	W	SW	SE	E	S	E	SE	SE	SE	W
Slope (degrees)		5	25	15	35	25	25	15	5	5	3	15	3	7	10	35
Hight of the canopy layer (m)		6	9	8	8	10	9	4	6	6	6	7	8	9	8	13
Cover total (%)		100	90	100	80	70	95	95	80	90	80	90	90	70	80	100
Cover A (%)		100	90	100	80	100	90	0	80	90	80	90	90	70	80	60
Cover B (%)		20	50	50	25	25	20	90	20	10	10	20	20	50	40	15
Cover C (%)		5	60	20	50	90	60	20	30	20	40	30	20	90	90	70
Cover bare rock (%)		50	0	10	0	0	20	0	10	10	40	5	0	20	20	0
Characteristic species of the association																
Carpinus orientalis	A	5	4	5	4	4	4	.	4	4	4	5	5	4	4	2
Carpinus orientalis	B	1	.	.	1	1	1	4	2	2	2	1	2	1	1	3
Acer obtusatum	A	.	1	1	.	1	2	.	+	.	+	+	.	.	.	1
Acer obtusatum	B	+	.	+	+	2	+	.	+	.	2	2	+	+	+	.
Potentilla micrantha	C	+	.	+	+	+	.	+	1	+	1	+	1	+	+	.
Brachypodium sylvaticum	C	1	3	+	1	.	.	1	1	1	1	+	1	2	1	+
Lathyrus vernus+venetus	C	.	1	+	.	+	+	.	+	+	.	r	+	1	+	+
Glechoma hirsuta	C	+	.	.	+	.	.	1	1	1	1	1	+	1	1	.
Pulmonaria officinalis	C	r	.	.	+	.	.	+	+	1	.	+	r	+	+	+
Festuca heterophylla	C	.	+	2	.	.	.	1	1	r	+	+	1	1	1	.
Asarum europaeum	C	.	+	.	.	+	.	+	1	r	.	+	+	1	1	+
Polypodium vulgare	C	.	+	.	+	+	.	+	r	r	+	.	.	+	.	+
Erythronio-Carpinion																
Carpinus betulus	A	.	.	.	.	.	+	.	1	1	.	+	+	1	1	.
Carpinus betulus	B	.	+	.	.	.	.	2	2	.	.	1	1	.	.	.
Ruscus aculeatus	B	.	3	+	2	2	1	.	.	.	.	+	.	.	.	2
Ruscus hypoglossum	B	.	+	.	+	+	1	.	.	.	.	.	.	.	.	+
Helleborus odorus	C	+	+	+	+	1	1	1	1	1	1	+	1	1	1	+
Cyclamen purpurascens	C	.	1	+	+	+	1	.	+	2	1	+	.	1	1	+
Primula acaulis	C	.	+	.	+	.	.	1	+	+	.	+	+	+	+	.
Epimedium alpinum	C	.	3	.	r	+	.	1	.	.	.	+	.	.	.	+
Tamus communis	C	+	2	1	+	1	.	.	.	.	.	.	.	.	.	1
Carpino-Fagetea																
Crataegus monogyna	A	+	.	.	.	.	.	.	.	.	+	1	1	.	.	.
Crataegus monogyna	B	+	2	+	+	.	.	2	+	1	2	2	2	1	.	.
Quercus petraea	A	1	+	1	.	2	1	.	.	.	.	.	.	.	.	.
Quercus petraea	B	1	.	1	.	+	+	.	+	2	.	+	+	.	1	+
Acer campestre	A	.	.	.	.	.	1	.	.	.	1	+	.	.	.	.

Relevé number		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Acer campestre	B	1	.	+	+	+	2	2	.	.	.	2	+	+	.	1
Rosa arvensis	B	1	+	+	+	+	.	.	+	+	+	+	+	+	+	+
Hedera helix	B	1	2	1	3	1	1	.	1	1	2	+	.	1	2	3
Ligustrum vulgare	B	.	1	.	+	.	1	1	+	+	1	1	+	+	+	.
Clematis vitalba	B	r	+	.	.	+	.	+	r	1	.	.	+	r	.	.
Rubus hirtus	B	.	.	.	.	.	+	+	+	+	.	+	.	.	.	.
Corylus avellana	B	.	.	.	.	.	+	1	.	.	.	r	.	.	.	.
Cruciata glabra	C	.	3	+	+	+	.	+	+	+	+	1	1	+	+	+
Aremonia agrimonoides	C	+	.	.	.	.	.	1	1	1	+	.	+	+	+	.
Symphytum tuberosum	C	.	+	+	.	+	+	.	r	.	.	+	+	+	r	.
Ajuga reptans	C	+	1	.	+	.	.	1	.	.	.	r	.	+	+	r
Dactylis glomerata	C	+	.	+	+	.	+	.	+	.	+	.	.	.	.	+
Carex sylvatica	C	+	.	.	.	.	.	+	+	+	.	.	+	2	1	.
Luzula forsteri	C	.	.	+	.	.	.	.	r	+	+	.	+	+	1	.
Carex digitata	C	.	.	.	+	+	1	.	.	.	.	+	.	1	2	r
Sanicula europaea	C	.	+	.	.	.	.	.	+	.	.	+	+	.	+	.
Drymochloa drymeia	C	.	.	.	+	5	1	.	+	.	+	.	.	.	.	.
Hepatica nobilis	C	.	.	.	+	.	+	.	.	.	.	+	.	+	1	.
Euphorbia amygdaloides	C	.	.	.	r	.	.	.	.	.	.	+	.	+	+	+
Stellaria holostea	C	.	+	.	.	.	.	.	.	+	1	.	.	1	.	.
Bromus benekenii	C	.	.	r	.	.	.	.	.	.	r	+	.	.	.	2
Daphne laureola	B	.	.	.	+	.	.	.	+	+	.	.	.	.	.	+
Polystichum setiferum	C	.	.	.	+	.	.	.	r	+	.	.	.	.	.	+
Geum urbanum	C	.	.	.	+	.	.	.	.	r	+	.	.	+	.	.
Viola reichenbachiana	C	.	.	.	.	.	.	+	.	+	.	+	+	.	.	.
Melica uniflora	C	.	+	+	.	.	.	.	.	r	.	.	.	.	.	.
Veronica chamaedrys	C	.	.	+	+	.	r	.	.	.	.	.	.	.	.	.
Galium schultesii	C	.	.	r	r	.	.	.	.	.	.	.	.	.	+	.
Carex pilosa	C	.	.	.	.	.	3	.	.	.	.	.	.	+	3	.
Quercetea pubescentis																
Fraxinus ornus	A	2	2	1	2	3	2	.	.	+	1	+	+	1	1	.
Fraxinus ornus	B	2	.	1	+	+	2	.	.	2	2	2	2	1	1	.
Euonymus verrucosus	B	.	2	.	+	1	r	.	.	.	+	+	.	+	1	.
Cornus mas	A	1	.	.	.	1	1	.	.	.	.	.	.	.	1	.
Cornus mas	B	+	.	.	2	.	1	2	.	2	.	1	.	1	2	2
Sorbus torminalis	A	1	.	2	.	.	.	.	.	.	.	.	.	.	.	.
Sorbus torminalis	B	1	.	+	+	.	.	.	.	.	.	2	1	1	.	1
Cotinus coggygria	A	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cotinus coggygria	B	1	.	.	.	+	.	.	.	.	.	.	.	+	.	+
Viburnum lantana	B	+	1	.	.	2	.	+	.	.	.	+	.	1	.	+
Tilia tomentosa	B	.	.	.	.	+	2	.	.	.	.	.	.	1	.	.
Carex flacca	C	.	.	.	+	.	.	1	.	.	.	2	1	.	r	.
Viola hirta	C	+	.	+	+	+	.	.	.	.	.	.	+	.	.	.
Campanula persicifolia	C	.	.	+	+	+	+	.	+	.	.	.	.	.	.	.

Relevé number		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Lathyrus niger	C	r	.	+	.	+	.	.	.	.	.	.	.	+	.	.
Melittis melissophyllum	C	.	+	.	.	+	.	.	.	.	.	.	.	.	.	+
Aegonychon purpurocaeruleum	C	1	.	+	+	.	.	.	.	.	.	.	.	.	.	.
Asplenium adiantum-nigrum	C	.	.	.	+	.	+	.	.	.	.	.	.	.	.	+
Asplenium ceterach	C	.	.	.	+	.	.	.	.	r	+	.	.	.	.	.
Allium carinatum	C	.	.	.	.	.	.	.	r	+	r	.	.	.	.	.
Silene nutans	C	.	.	.	.	.	.	.	.	.	1	.	.	+	+	.
Companions																
Acer tataricum	B	r	.	r	+	+	.	.	.	.	.	+	.	1	1	.
Juniperus communis	B	+	+	.	.	.	.	+	r	.	.	.	+	+	.	.
Fragaria moschata	C	.	.	+	.	.	.	.	.	.	.	.	.	+	+	.
Asplenium trichomanes	C	.	.	.	+	.	.	.	.	r	.	.	.	.	.	+

In one or two relevés:

A: Sorbus torminalis 1: 1, 3: 2; Cotinus coggygria 1: 1; Quercus cerris 2: +; Tilia tomentosa 5: 1, 6: 1; Ostrya carpinifolia 9: +, 10: +; Quercus pubescens 1: 1; Prunus avium 9: +; Fagus sylvatica 12: +; Fraxinus excelsior 15: 1;

B: Cornus sanguinea 2: +; Quercus cerris 7: 2; Pyrus communis ssp. pyraster 1: +, 12: +; Fagus sylvatica 3: +, 7: 2; Staphylea pinnata 4: +, 5: 2; Euonymus latifolius 4: +, 5: +; Euonymus europaeus 7: +, 11: +; Ostrya carpinifolia 9: 2, 10: 2; Prunus avium 9: 2, 11: 2; Quercus pubescens 1: 1; Prunus spinosa 1: r; Rhamnus cathartica 2: 1; Cytisus hirsutus 2: 1; Ulmus minor 8: +; Tilia platyphyllos 8: r; Quercus robur 13: 2; Tilia cordata 15: +; Fraxinus excelsior 15: +;

C: Sesleria autumnalis 8: +, 14: +; Cephalanthera longifolia 2: +, 7: r; Mercurialis perennis 4: +, 15: +; Iris graminea 4: 1; Lilium martagon 5: +; Pteridium aquilinum 7: +; Vincetoxicum hirundinaria 1: r, 4: +; Melica nutans 2: 1, 4: +; Melampyrum pratense 2: +, 4: +; Aristolochia lutea 2: +, 7: 1; Galium sylvaticum 2: +, 11: +; Fragaria vesca 2: +, 15: +; Campanula trachelium 3: +, 4: +; Polygonatum multiflorum 3: +, 9: +; Hylotelephium maximum 3: +, 11: r; Pseudoturritis turrita 4: +, 9: +; Asplenium scolopendrium 4: +, 15: +; Cardamine bulbifera 6: +, 9: +; Galanthus nivalis 6: r, 9: +; Taraxacum officinale 8: r, 9: r; Peltaria alliacea 9: +, 10: +; Arum maculatum 9: +, 11: +; Geranium robertianum 9: r, 10: +; Aposeris foetida 11: 1, 12: 1; Melampyrum nemorosum 11: +, 14: +; Galium verum 2: 2; Thymus pulegioides 2: +; Poa angustifolia 2: +; Luzula campestris 2: +; Asplenium ruta-muraria 2: +; Chaerophyllum hirsutum 3: r; Platanthera bifolia 3: r; Holcus lanatus 3: r; Lamium galeobdolon 4: +; Peucedanum austriacum 4: +; Piptatherum virescens 4: +; Silene viridiflora 4: +; Polygonatum odoratum 4: r; Anemone ranunculoides 6: +; Erythronium dens-canis 6: +; Orchis pallens 6: r; Orchis simia 7: +; Campanula bononiensis 7: r; Filipendula vulgaris 7: r; Corydalis cava 9: +; Neottia nidus-avis 9: +; Crocus vernus 9: +; Scilla bifolia 9: r; Galium mollugo 10: +; Orchis purpurea 11: 1; Anemone nemorosa 11: +; Smyrnium perfoliatum 13: +; Ornithogalum pyrenaicum 13: +; Peucedanum carvifolia 13: r; Pastinaca sativa 14: r.

Details of relevés (indicated in the following order: relevé number, GIVD EU-BA-001 relevé number, date (year/month/day), description of locality, longitude, latitude, bedrock): 1) 309, 2014/06/24, Ćićina kosa, Gradina (Bočac), 17.147586, 44.545781, limestone; 2) 1073, 1998/04/28, Cer (Starčevica), 17.212744, 44.7504, dolomite; 3) 3026, 2017/05/02, Jagare (Starčevica), 17.207547, 44.712043, limestone; 4) 3579, 2014/08/19, Magareći potok (Starčevica), 17.184836, 44.745235, dolomite; 5) 3580, 2014/07/31, Trešnjik (Starčevica), 17.17307, 44.73713, dolomite; 6) 3632, 2020/04/03, Drenovača (Ponir), 17.221471, 44.747957, limestone; 7) 3636, 2020/04/05, Donja Kola (Manjača), 17.090543, 44.749972, dolomite; 8) 3638, 2020/04/09, above Vrbas canyon (Ljubačevo), 17.18372, 44.683289, limestone; 9) 3639, 2020/04/09, above Vrbas canyon (Ljubačevo), 17.184923, 44.682865, limestone; 10) 3640, 2020/04/09, Grabež Mala (Ljubačevo), 17.187266, 44.680652, limestone; 11) 3642, 2020/04/09, Savići (Rekavice), 17.13603, 44.674709, limestone; 12) 3643, 2020/04/09, Rekavice, 17.131842, 44.679936, marl limestone; 13) 3644, 2020/04/10, Krupa na Vrbasu, 17.135722, 44.617552, limestone; 14) 3645, 2020/04/10, Krupa na Vrbasu, 17.137349, 44.618658, limestone; 15) 3578, 2014/07/30, Banj brdo (Starčevica), 17.174481, 44.746997, dolomite.

Table 3: *Asplenio scolopendrii-Carpinetum orientalis* ass. nov. hoc loco, holotypus: relevé 6 (A – canopy layer (> 5 m), B – understory layer (< 5 m), C – herb layer).

Tabela 3: *Asplenio scolopendrii-Carpinetum orientalis* ass. nov. hoc loco, holotip: popis 6 (A – drevesna plast (> 5 m), B – grmovna plast (< 5 m), C – zeliščna plast).

Relevé number		1	2	3	4	5	6	7	8
Relevé area (m2)		400	100	400	100	400	400	225	225
Altitude (m)		313	330	350	215	317	406	220	230
Aspect		NE	NE	N	NW	E	N	NW	NE
Slope (degrees)		45	45	50	45	35	40	35	50
Hight of the canopy layer (m)		8	8	7	10	10	8	8	10
Cover total (%)		100	100	100	100	80	100	100	85
Cover A (%)		100	100	100	90	80	100	45	80
Cover B (%)		20	10	0	30	50	30	80	25
Cover C (%)		60	50	50	50	50	80	40	50
Cover bare rock (%)		80	50	70	90	75	60	50	80
Characteristic species of the association									
Carpinus orientalis	A	5	3	4	5	4	5	1	5
Carpinus orientalis	B	2	+	2	2	2	2	3	.
Polystichum setiferum	C	4	+	3	2	1	1	2	3
Asplenium scolopendrium	C	3	2	2	2	2	1	2	2
Asplenium trichomanes	C	1	1	+	+	1	+	1	1
Asplenium ceterach	C	+	+	.	+	1	+	+	+
Polypodium vulgare	C	1	.	2	1	3	2	1	1
Saxifraga rotundifolia	C	+	+	1	+	+	1	+	+
Veratrum nigrum	C	2	1	2	+	.	+	r	+
Geranium robertianum	C	1	+	+	+	1	.	+	+
Carex digitata	C	+	+	+	+	.	+	+	+
Ostryo-Tilion									
Fraxinus ornus	A	1	2	3	.	2	1	1	1
Fraxinus ornus	B	2	1	2	.	2	2	2	+
Ostrya carpinifolia	A	.	2	.	1	1	.	2	1
Ostrya carpinifolia	B	.	.	.	.	.	+	2	.
Tilia tomentosa	A	1	.	1	.	.	.	.	.
Tilia tomentosa	B	1	.	+	.	.	1	.	.
Acer monspessulanum	A	+	1	1	1	.	.	.	.
Hedera helix	B	+	.	+	+	2	.	+	+
Euonymus verrucosus	B	.	+	+	+	.	.	+	1
Staphylea pinnata	A	+	2	.	.	.	.	.	.
Staphylea pinnata	B	+	1	.	.	.	.	2	.
Sambucus nigra	B	.	.	.	+	.	.	2	+
Tilia platyphyllos	B	.	.	.	+	.	.	+	+
Helleborus odorus	C	1	.	+	+	+	1	+	+
Hepatica nobilis	C	+	1	+	+	.	r	+	+
Cyclamen purpurascens	C	r	.	+	+	2	.	.	.
Lathyrus vernus+venetus	C	+	.	r	+	.	1	+	+
Peltaria alliacea	C	+	.	+	+	.	r	.	.
Arum maculatum	C	r	.	.	.	+	.	.	+
Fagetalia									
Corylus avellana	A	.	1	.	.	.	.	.	.
Corylus avellana	B	.	1	.	.	+	.	1	.
Euonymus europaeus	B	.	+	.	+	+	.	.	+

Relevé number		1	2	3	4	5	6	7	8
Dactylis glomerata	C	+	+	1	+	+	2	.	+
Mercurialis perennis	C	+	1	r	+	+	.	.	.
Lamium galeobdolon	C	+	+	+	+	.	.	+	.
Veronica chamaedrys	C	r	.	r	.	+	r	.	+
Galium sylvaticum	C	.	+	.	+	.	.	+	+
Glechoma hirsuta	C	.	.	.	.	1	+	+	+
Symphytum tuberosum	C	+	+	+	.	.	+	.	.
Brachypodium sylvaticum	C	+	+	.	+	+	.	.	.
Cardamine bulbifera	C	+	.	1	.	+	.	.	.
Campanula trachelium	C	r	.	r	.	.	+	+	.
Geum urbanum	C	.	.	.	r	+	+	.	+
Galium schultesii	C	+	.	+	.	.	+	.	.
Polygonatum multiflorum	C	+	+	+	.	.	.	.	.
Asarum europaeum	C	+	+	.	.	.	r	.	.
Silene dioica	C	+	.	1	.	.	.	.	+
Galanthus nivalis	C	+	.	+	.	+	.	.	.
Melica uniflora	C	+	.	.	+	.	.	.	1
Ruscus hypoglossum	B	+	.	.	.	.	.	.	+
Lactuca muralis	C	.	+	.	r	+	.	.	.
Cardamine impatiens	C	r	.	r	.	.	.	.	+
Quercetea pubescentis									
Cornus mas	A	1	3	.	1	1	.	.	.
Cornus mas	B	1	1	2	2	2	2	2	2
Sesleria autumnalis	C	+	1	1	+	.	2	.	.
Campanula persicifolia	C	+	.	r	.	.	+	.	.
Potentilla micrantha	C	+	.	1	+	.	.	.	.
Companions									
Pseudoturritis turrita	C	+	.	.	.	+	+	.	.
Valeriana officinalis	C	r	+	r	.	.	.	.	.
Verbascum nigrum	C	r	.	r	r	.	.	.	.

In one or two relevés:
A: Staphylea pinnata 1: +, 2: 2; Crataegus monogyna 2: 1, 8: +; Corylus avellana 2: 1, 9: +; Acer obtusatum 5: 1, 9: 1; Carpinus betulus 5: 1, 9: +; Acer hyrcanum ssp. intermedium 2: 1; Tilia cordata 2: 1; Sorbus aria 3: 1; Tilia platyphyllos 7: 1; Acer campestre 7: 1; Ulmus glabra 5: 1; Ulmus minor 9: +;
B: Cotinus coggygria 2: 1, 6: +; Ostrya carpinifolia 6: +, 7: 2; Ruscus aculeatus 1: +, 6: 1; Acer campestre 1: r, 3: r; Crataegus monogyna 2: 1, 4: +; Acer monspessulanum 2: 1, 4: +; Viburnum lantana 2: +, 4: r; Ulmus minor 4: +, 7: +; Acer obtusatum 5: 2, 9: 1; Hippocrepis emerus ssp. emeroides 6: 1; Ligustrum vulgare 1: +; Rosa arvensis 1: +; Tilia cordata 2: +; Sorbus aria 3: +; Daphne laureola 5: 1; Lonicera xylosteum 7: +; Quercus robur 7: r; Clematis vitalba 8: +; Crataegus laevigata 9: +;
C: Viola hirta 1: +, 3: r; Hylotelephium maximum 4: +, 6: +; Moehringia trinervia 1: +, 3: +; Tamus communis 1: +, 6: r; Smyrnium perfoliatum 1: r, 6: +; Arabidopsis arenosa 4: +, 8: +; Poa angustifolia 6: +, 8: +; Fragaria moschata 6: r; Stellaria holostea 1: +; Carex sylvatica 1: +; Primula acaulis 1: +; Alliaria petiolata 1: +; Epimedium alpinum 2: 1; Clematis recta 2: +; Convallaria majalis 2: +; Laserpitium krapfii ssp. krapfii 2: +; Asplenium ruta-muraria 2: +; Euphorbia amygdaloides 2: +; Vincetoxicum hirundinaria 2: +; Symphyandra hofmannii 2: r; Lilium martagon 2: r; Tanacetum corymbosum 2: r; Urtica dioica 2: r; Adoxa moschatellina 3: r; Pulmonaria officinalis 4: +; Scutellaria altissima 4: r; Carex divulsa ssp. leersii 5: +; Galium lucidum 5: +; Arum italicum 5: +; Poa nemoralis 5: +; Anemone ranunculoides 5: +; Cardamine hirsuta 5: r; Galium aparine 5: r; Digitalis grandiflora 6: +; Cruciata glabra 6: +; Isopyrum thalictroides 6: +; Geranium lucidum 6: r; Lunaria rediviva 7: +; Viola reichenbachiana 7: +; Inula conyza 7: +; Parietaria officinalis 7: +; Pseudofumaria alba ssp. leiosperma 8: +.

Details of relevés (indicated in the following order: relevé number, GIVD EU-BA-001 relevé number, date (year/ month/day), description of locality, longitude, latitude):
1) 2936, 2015/05/14, Ispod Greben grada (Krupa na Vrbasu), 17.13748, 44.61054; 2) 3109, 2018/06/21, Kanjon Crne rijeke (desna obala), 17.165446, 44.463635; 3) 2935, 2015/05/14, Ispod Greben grada (Krupa na Vrbasu), 17.137663, 44.610092; 4) 3102, 2018/06/20, Kanjon Vrbasa (desna obala, Tijesno), 17.197794, 44.68809; 5) 3646, 2020/04/15, Čelinski potok (Starčevica), 17.267045, 44.726266; 6) 2933, 2015/05/14, Ispod Greben grada (Krupa na Vrbasu), 17.137304, 44.609612; 7) 3613, 2018/06/20, Kanjon Vrbasa (desna obala, Tijesno), 17.197921, 44.687727; 8) 3610, 2018/06/20, Kanjon Vrbasa (desna obala, Tijesno), 17.19911, 44.68801.