

## ASSEMBLAGE, ZOOGEOGRAPHY AND ENDANGERED STATUS OF CARABID BEETLES IN FOREST HABITATS OF THE UČKA NATURE PARK

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Accepted: October 28<sup>th</sup> 2010

The aim of this study was to analyse the ground beetle assemblage (Coleoptera: Carabidae) in the forest habitats of the Učka Nature Park, their zoogeographical distribution and status in the Croatian Red list of ground beetles. Pitfall traps were placed in eleven plots in seven forest communities in Mt Učka and exposed during 2008. Thirty-five carabid species were recorded, eight of which are endemic. The zoogeographic positions of species were in accordance with the geographical location of Mt Učka, which is located on the border line of two zoogeographical regions, the Mediterranean and the Euro-Sibirean-North American region with Alpine elements. One quarter of the recorded species are present in the Croatian Red list of ground beetles. One very important finding was that of *Carabus variolosus nodulosus* Creutzer 1799 which is given in the Croatian Red list with the status of vulnerable. It is also listed in Appendix II and IV of the Convention on the conservation of European wildlife and natural habitats (Council Directive 92/43/EEC).

### Carabid species, Mt Učka, Red list of ground beetles

I. RUKAVINA, A. MRAZOVIĆ, M. KUČINIĆ i L. ŠERIĆ JELASKA. Vrste trčaka, zoogeografska pripadnost i status zaštite u šumskim staništima na području Parka prirode Učka. Entomol. Croat. 2010. Vol. 14. Num. 1-2: 121-134.

Cilj ovog istraživanja bio je utvrditi sastav vrsta trčaka (Coleoptera: Carabidae) u šumskim staništima na području Parka prirode Učke, njihovu zoogeografsku pripadnost i status zaštite. U sedam šumskih zajednica na području parka odabrano je jedanaest ploha, a trčci su uzorkovani metodom

lovnih posuda tijekom vegetacijske sezone u 2008. godini. Utvrđeno je 35 vrsta, od čega je osam endemskih, a njihov sastav s obzirom na zoogeografsku rasprostranjenost u skladu je s položajem Učke na razmeđi mediteranske i eurosibirske-sjevernoameričke regije s prisutnim alpskim elementima. Četvrtina zabilježenih vrsta nalazi se na Crvenom popisu svojti trčaka RH. Faunistički je značajan nalaz čvorastog trčka (*Carabus variolosus nodulosus* Creutzer 1799) koji se smatra ugroženom vrstom, a nalazi se na Crvenom popisu kao osjetljiva vrsta (VU) te na Dodatku II i IV Direktive o zaštiti prirodnih staništa i divlje faune i flore (DIRECTIVE 92/43/EEC).

### Trčci, Učka, Crveni popis trčaka

## Introduction

At the beginning of 18th century Scopoli started entomological research into the Bay of Kvarner and the adjacent mountain area. Since then, more than 150 entomologists have conducted research in this area (Britvec & Milošević, 1998). At the end of the 19th century, the most important investigations with respect to Mt Učka were carried out by Beszedesz, who assembled a large collection of specimens. During the 20th century, Depoli and Goidanich (Depoli 1926-1940), Müller (1926), and Durbešić (1983a and b) continued with entomological researches on Mt Učka. At the end of the 20th and the beginning of this century, ground beetle fauna was studied mostly in forest ecosystems of Hrvatsko primorje and Gorski kotar areas, especially in protected parts such as Risnjak National Park, Medvednica and Papuk Nature Parks (Durbešić, 1986; Durbešić et al., 1994; Vujčić-Karlo, 1999; Šerić Jelaska 2005; Šerić Jelaska et al. 2007 and 2010; Šerić Jelaska & Durbešić, 2009). These investigations enhanced ground beetle fauna lists and extended the understanding of the distribution of ground beetle species in Croatia, especially in mountain forest ecosystems. Mt Učka encloses the Istria peninsula with its specific geographical position and divides it from the rest of Croatia (Durbešić 1983 a and b). Učka is one of the highest mountains in Croatia, its highest peak being Vojak (1401 m). Učka Nature Park was founded in 1999, merging Mt Učka and adjacent part of the Čićarija plateau. 72.18% of the Učka Nature Park is forested (Ministry of Environmental Protection, Physical Planning and Construction, 2003), with a clear zonation of forest communities. Vojak Peak

(1401 m), is covered with altimontane beech forest with coltsfoot (*Homogyno alpinae-Fagetum*) but most of the beech forests on Mt Učka descending to the altitude of around 700 m pertain to beech forest with autumn moor grass (*Seslerio autumnalis-Fagetum*). Below this the region is dominated by the forest of pubescent oak and hop hornbeam (*Ostryo-Quercetum pubescentis*). Lower and warmer parts are covered with communities of pubescent oak and oriental hornbeam (*Quercu-Carpinerum orientalis*) and communities of sessile oak and sweet chestnut (*Quercu-Castaneetum sativae*). Large areas on Mt Učka have been afforested with conifers, mostly with black pine (*Pinus nigra*). Other habitats such as rocks, screes, grasslands, shrubs, weed vegetation and freshwater habitats cover 18.67% of the Nature Park while the rest is occupied by (9.15%) rural settlements, infrastructure and agricultural land. The high biodiversity of grassland vegetation in the Nature Park is the result of deforestation during centuries of livestock farming. Nowadays, succession processes are gathering apace, due to the cessation of arable farming and grazing. Rocks and screes are very important as the habitats of rare and endemic plant species.

International Union for Conservation of Nature (IUCN), faced with species decline, established criteria assessing the vulnerability of certain species and according to these criteria, red lists and red books have been made. Red lists and books represent the fundamentals of nature protection because they indicate which species and subspecies are endangered and to what extent ([http://www.dzpp.hr/crveni\\_popis.htm](http://www.dzpp.hr/crveni_popis.htm)). A Red List of ground beetles has been elaborated for the Croatian area ([http://www.dzpp.hr/publikacije/crveni\\_popis\\_trhci.pdf](http://www.dzpp.hr/publikacije/crveni_popis_trhci.pdf)).

The aim of this study was to determine which ground beetles species inhabit different forest communities in Učka Nature Park in order to supplement the existing list of ground beetles for the study area, to confirm their zoogeographical position and ascertain the presence of protected species and the proportion of endemic species according to the Croatian Red List of ground beetles. The results of the study will enable better evaluation of the study area in order to improve the management of Učka Nature Park with the aim of nature protection and conservation.

## Materials and methods

### Study area and data sampling

The study area was located within Učka Nature Park. Eleven plots were established in different forest communities (Figure 1, Table 1.) including all forest communities of the area.

Table 1. Investigated plots with additional marks, forest communities, geographical coordinates (Transverse-Mercator projection on Bessel spheroid in 5<sup>th</sup> zone with Gauß-Krüger coordinates) and altitude.

Tablica 1. Istraživani lokaliteti s oznakama, šumske zajednice, geografske koordinate i nadmorske visine (univerzalna poprečna Mercatorova projekcija na Bessel kuglu u 5. zona sa Gauß-Krüger koordinatama).

Plot - Name	Plot mark	Forest community	X-coordinate	Y- coordinate	Altitude (m)
Vojak	VO	<i>Homogyno alpinae-Fagetum</i>	5438043,24203	5016243,79525	1320
Planik	PL	<i>Seslerio-Fagetum</i>	5436668,27004	5023493,61338	1052
Kava	KA	<i>Pinus nigra</i>	5437042,50842	5015954,53257	1019
Na Dole	ND	<i>Lamio orvalae-Fagetum</i>	5439103,41685	5015395,03629	986
Partizanska bolnica	PB	<i>Seslerio-Fagetum</i>	5438917,62749	5017018,98413	868
Bukovo	BU	<i>Seslerio-Fagetum</i>	5436899,32365	5002418,56934	673
Trebišća 3	TR3	<i>Lamio orvalae-Fagetum</i>	5438897,09401	5012594,07626	435
Lovranska Draga 1	LD1	<i>Ostryo-Quercetum pubescentis</i>	5440912,46392	5015662,37679	409
Trebišća 2	TR2	<i>Seslerio-Fagetum</i>	5439110,76928	5012660,60439	405
Lovranska Draga 2	LD2	<i>Querco-Castaneetum sativae</i>	5440889,12873	5015498,48709	385
Trebišća 1	TR1	<i>Querco-Carpinetum orientalis</i>	5440546,48969	5011630,12408	130

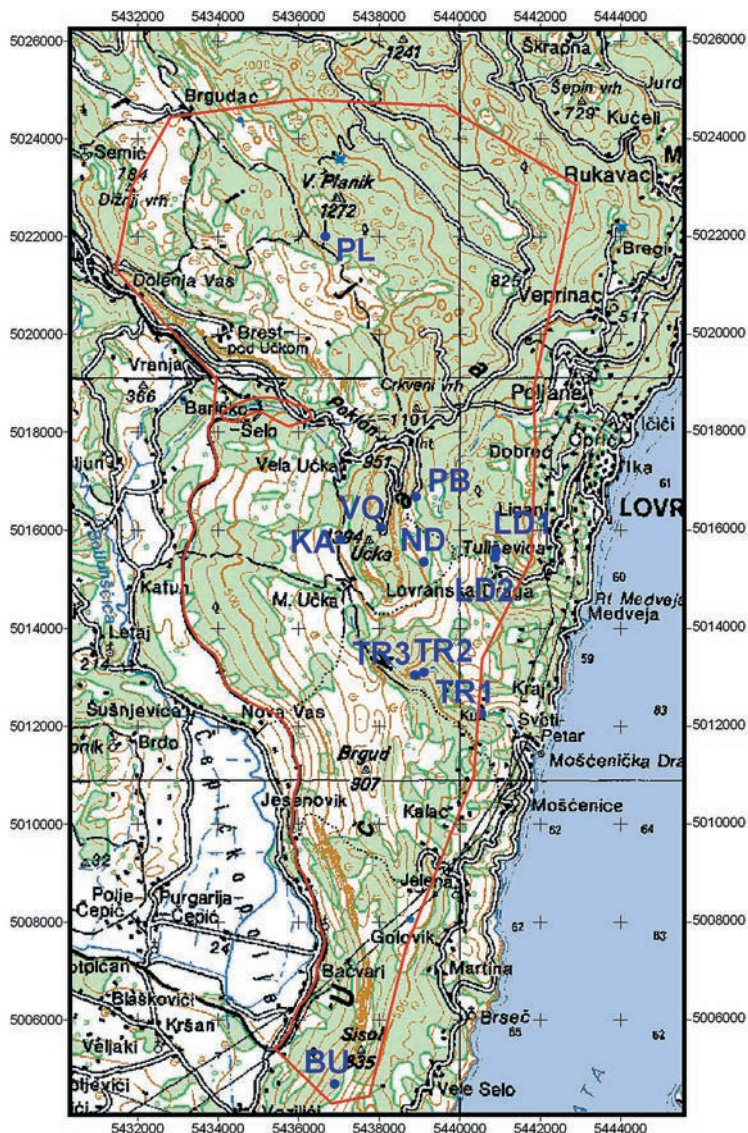


Figure 1. Plot locations in the Učka Nature Park. Plot labels as in Table 1. (Transverse-Mercator projection on Bessel spheroid in 5<sup>th</sup> zone with Gauß-Krüger coordinates)

Slika 1. Karta lokaliteta u Parku prirode Učka s lokalitetima kao u tablici 1. (univerzalna poprečna Mercatorova projekcija na Bessel kuglu u 5. zona sa Gauß-Krüger koordinatama).

Four plots were set up in beech forests with autumn moor grass (*Seslerio-Fagetum*) covering majority of the area. Two plots were distinguished in Illyricum forests of mountain beech forests with giant dead nettle (*Lamio orvalae-Fagetum*). All the other communities hosted one plot (Table 1). Altitude and geographical coordinates were identified using a GPS (Global Positioning System) receiver (Table 1).

Carabid beetles were collected by means of pit-fall traps. Five pit-fall traps were placed in a square chosen randomly in each study site; four pit-fall traps were placed at the points of the square and one in the centre. The size of the square was 10x10 m. This rule was dispensed with at plots VO and TR2 due to field configuration. The traps were 500-ml plastic cups (10 cm diameter) filled with ca 150 ml of ethanol (96%), acetic acid (9%) and water in equal proportions and covered with Styrofoam roofs to prevent evaporation and to protect them from rain. The traps were emptied five times in all at intervals of three weeks from May to October 2008, excluding August when the traps were closed with wooden lids. All carabid beetles were stored in vials containing 70% ethanol and were later counted and classified to species level.

## Data analysis

Species were identified using the identification guides of Freude et al. (2004) and Hůrka (1996) and museum collections in National History Museum in Rijeka. Nomenclature was adjusted with the updated carabid list of the Palearctic area *Catalogue of Palaearctic Coleoptera*, Vol. 1 (Löbl & Smetana, 2003). The list of ground beetles collected in this research has been compared with ground beetle lists published in the studies of Müller (1926), Depoli (1926-1940) and Durbešić (1983 a and b) previously conducted in the same study area. Level of vulnerability is specified using Red List of ground beetles published on the Internet pages of the Croatian State Institute for Nature Protection ([http://www.dzpp.hr/publikacije/crveni\\_popis\\_trchci.pdf](http://www.dzpp.hr/publikacije/crveni_popis_trchci.pdf)). Zoogeographical analysis has been made according to the identification guide Freude et al. (2004) and the database Fauna Europaea (<http://www.faunaeur.org/distribution.php>).



## Results and discussion

Thirty-five species of ground beetles were collected (Table 2). *Abax parallelepipedus* (Piller&Mitterpacher 1783) and *Carabus caelatus* Fabricius 1801 were recorded in all plots. *Aptinus bombarda* (Illiger 1800) and *Laemostenus elongatus* (Dejean 1828) were also present in all plots, excluding LD2, while *Abax ovalis* (Duftschmid 1812) was not captured only in plot VO. *Carabus hortensis* Linné 1758 (plot BU), *Carabus variolosus nodulosus* Creutzer 1799 (plot TR2), *Molops ovipennis* Chaudoir 1847 (plot TR2), *Harpalus dimidiatus* (Rossi 1790) (plot TR2), *Harpalus affinis* (Schrank 1781) (plot TR2), *Notiophilus biguttatus* (Fabricius 1779) (plot KA), *Notiophilus rufipes* Curtis 1829 (plot KA), *Poecilus koyi lossinianus* Fairmaire 1860 (plot LD2) and *Calathus glabricollis* Dejean 1828 (plot LD2) were recorded in only one plot (Table 2). Six species were not recorded in the previous research work of Müller (1926), Depoli (1926-1940) and Durbešić (1983a and b): *Carabus hortensis* Linné 1758, *Harpalus affinis* (Schrank 1781), *Laemostenus elongatus* (Dejean 1828), *Leistus rufomarginatus* (Duftschmid 1812), *Notiophilus rufipes* Curtis 1829, and *Pseudoophonus rufipes* (DeGeer 1774).

One quarter of the collected species are included in the Croatian Red list of ground beetles: *Carabus variolosus nodulosus* Creutzer 1799, *Myas chalybaeus* (Palliard 1825), and *Poecilus koyi lossinianus* Fairmaire 1860 are considered vulnerable (VU), while *Carabus caelatus* Fabricius 1801), *Licinus hoffmannseggii* (Panzer 1797), *Molops ovipennis* Chaudoir, 1847, *Molops piceus* (Panzer 1793) and *Nebria dahlii* (Duftschmid 1812) are indicated as nearly threatened (NT) (Table 3). *Carabus catenulatus* Scopoli 1763 and *Crabus creutzeri* Fabricius 1801 have the status of least concern (LC). The declining European ground beetle *Carabus variolosus nodulosus* Creutzer 1799, indicator of undisturbed woodland brooks and swamps and listed in the Appendix II and IV of the Convention on the conservation of European wildlife and natural habitats (Council Directive 92/43/EEC) (Matern et al., 2008), was collected on plot TR2 located near the brook in the beech forest with autumn moor grass (*Sesleria autumnalis-Fagetum*). Although *Carabus variolosus nodulosus* Creutzer 1799, present in Croatia, is a subspecies of *Carabus variolosus* Fabricius 1787 (Šerić Jelaska et al., 2004), European entomologists agree that protection should extend to subspecies because of the similar ecological demands.

Table 2. List of ground beetle species in investigated plots in the Učka Nature Park.

Tablica 2. Popis vrsta trčaka i istraživani lokaliteti u Parku prirode Učka.

Species/Locations (Mt. Učka, 2008)	VO	PL	KA	ND	PB	BU	TR3	LD1	TR2	LD2	TR1
<i>Abax parallelepipedus</i> (Piller&Mitterpacher 1783)	x	x	x	x	x	x	x	x	x	x	x
<i>Abax carinatus</i> (Duftschmid 1812)							x	x	x	x	
<i>Abax ovalis</i> (Duftschmid 1812)		x	x	x	x	x	x	x	x	x	x
<i>Aptinus bombarda</i> (Illiger 1800)	x	x	x	x	x	x	x	x	x		x
<i>Calathus fuscipes</i> (Goeze 1777)	x	x	x						x	x	
<i>Calathus glabricollis</i> Dejean 1828											x
<i>Calosoma sycophanta</i> (Linné 1758)						x	x				
<i>Carabus caelatus</i> Fabricius 1801	x	x	x	x	x	x	x	x	x	x	x
<i>Carabus catenulatus</i> Scopoli 1763			x	x		x	x	x	x	x	x
<i>Carabus convexus</i> Fabricius 1775	x		x	x		x			x	x	x
<i>Carabus coriaceus</i> Linné 1758			x				x	x		x	x
<i>Crabus creutzeri</i> Fabricius 1801	x	x		x	x						
<i>Carabus hortensis</i> Linné 1758						x					
<i>Carabus variolosus nodulosus</i> Creutzer 1799									x		
<i>Carabus violaceus</i> Linné 1758			x					x		x	x
<i>Cychrus attenuatus</i> (Fabricius 1792)	x	x	x	x	x	x	x		x		
<i>Harpalus affinis</i> (Schrank 1781)									x		
<i>Harpalus dimidiatus</i> (Rossi 1790)									x		
<i>Laemostenus elongatus</i> (Dejean 1828)	x	x	x	x	x	x	x	x	x		x



Table 2. continued

Tabela 2. Nastavak

Species/Locations (Mt. Učka, 2008)	VO	PL	KA	ND	PB	BU	TR3	LD1	TR2	LD2	TR1
<i>Leistus rufomarginatus</i> (Duftschmid 1812)			x			x					x
<i>Leistus spinibarbis</i> (Fabricius 1775)			x	x							
<i>Licinus hoffmannseggii</i> (Panzer 1797)	x	x	x	x							
<i>Molops ovipennis</i> Chaudoir 1847									x		
<i>Molops piceus</i> (Panzer 1793)	x		x		x		x		x		x
<i>Molops striolatus</i> (Fabricius 1801)	x	x		x		x	x		x		
<i>Myas chalybaeus</i> (Palliard 1825)				x	x	x	x	x	x	x	
<i>Nebria brevicollis</i> (Fabricius 1972)	x		x								
<i>Nebria dahlii</i> (Duftschmid 1812)	x	x	x	x	x						
<i>Notiophilus biguttatus</i> (Fabricius 1779)			x								
<i>Notiophilus palustris</i> (Duftschmid 1812)			x							x	
<i>Notiophilus rufipes</i> Curtis 1829			x								
<i>Poecilus koyi lossinianus</i> Fairmaire 1860										x	
<i>Pseudophonus rufipes</i> (De Geer 1774)	x										x
<i>Pterostichus burmeisteri</i> Heer 1838	x	x		x							
<i>Stomis rostratus</i> (Duftschmid 1812)	x	x	x	x	x						

Due to the poor flying abilities and high habitat specificity *Carabus variolosus nodulosus* Creutzer 1799 this locality (plot TR2) on Mt Učka represents very important habitat and it is an area of special conservation interests according to the Habitats Directive in the NATURA 2000 programme in Croatia (Hrašovec, 2009). In the same plot, the Balkanic endemic species *Myas chalybaeus* (Palliard 1825), usually inhabiting highland areas and *Molops ovipennis* Chaudoir 1847, an alpine endemic species, were also recorded. At the higher altitudes, above 800 m, (plots VO, KA, PL, ND and PB), more species from the Red list were recorded than at lower altitudes. Because of the lower temperatures and ambient CO<sub>2</sub> concentration associated with greater altitudes, mountain forests may be particularly sensitive to global warming and increased atmospheric CO<sub>2</sub> (Smith et al., 2009). Although in Croatia there are no mountains as high as the Alps with typical alpine climate and habitats, there are some mountains with alpine flora and fauna. Generally, these high altitude areas are disjunct, small and isolated. High altitude species like *Crabus creutzeri* Fabricius 1801, *Molops ovipennis* Chaudoir 1847, *Molops striolatus* (Fabricius 1801), *Nebria dahlia* (Duftschmid 1812) and *Stomis rostratus* (Duftschmid 1812) inhabit Mt Učka in low-density populations. Plot LD2 in a forest community of sessile oak and hop hornbeam (*Quercus-Castaneetum sativae*) should be considered for additional protection, aside from the general protection measures for the whole Nature Park, as the only finding site of the *Poecilus koyi lossinianus* Fairmaire 1860, endemic subspecies of the islands Cres, Lošinj, Unija and Mt Učka. Middle European and north-western Balkan endemic species *Carabus caelatus* Fabricius 1801 with two endemic subspecies in Croatia (*C. caelatus dalmatinus* Duftschmid 1812 and *C. caelatus schreiberi* Kraatz 1877) was marked in each plot, while the alpine endemic species *Nebria dahlia* (Duftschmid 1812) was marked in plots at altitudes above 800 m. *Carabus catenulatus* Scopoli 1763, *Crabus creutzeri* Fabricius 1801 and *Stomis rostratus* Duftschmid 1812 should be mentioned as species collected in this study and although they are not listed on the Croatian Red list of ground beetles they belong either to Mediterranean, Alpine or Balkan endemic species (Table 3.). The specific position of Mt Učka on the borderline between two geographical regions, Mediterranean and Euro-Siberian – North American region, and the emphasized alpine elements contribute to the biodiversity of carabid fauna. Nevertheless, most of the collected species had a Balkan or south European zoogeographical distribution (Table 3.).

Table 3. Risk indication from the Croatian Red List species (LC – last concern, NT- nearly threatened, VU- vulnerable) and zoogeographical data of species collected on Mt. Učka (2008), (Eu - Europe, w - west, e - east, n - north, s - south, c - central, Balk - Balkan, As - Asia, Af - Africa, Med - Mediterranean region, Alp - alpine region, ES - Euro Siberian region, CR- Croatia, Pal - Palearctic region, Chin -China, Turan - Turan region, Cauc - Caucasus region, Alb - Albania, B&H - Bosnia and Herzegovina, It - Italy, Slo - Slovenia, Srb - Serbia, Mtn - Montenegro, Kos - Kosovo ).

Tabela 3. Kategorije ugroženosti prema Crvenoj listi Hrvatske i zoogeografska analiza prikupljenih vrsta na planini Učka 2008. godine.

Species (Učka 2008)	Croatian Red List of ground beetles	Zoogeographical region
<i>Abax parallelepipedus</i> (Piller&Mitterpacher 1783)		Eu
<i>Abax carinatus</i> (Duftschmid 1812)		e – Eu
<i>Abax ovalis</i> (Duftschmid 1812)		c – Eu
<i>Aptinus bombardata</i> ( Illiger 1800)		se – Eu
<i>Calathus fuscipes</i> ( Goeze 1777 )		Med, Iran
<i>Calathus glabricollis</i> Dejean 1828		w - Balk
<i>Calosoma sycophanta</i> (Linné 1758)		w – Pal
<i>Carabus caelatus</i> Fabricius 1801	NT	Balk
<i>Carabus catenulatus</i> Scopoli 1763	LC	c – Med
<i>Carabus convexus</i> Fabricius 1775		w – Pal
<i>Carabus coriaceus</i> Linné 1758		Eu
<i>Carabus creutzeri</i> Fabricius 1801	LC	Alp
<i>Carabus hortensis</i> Linné 1758		Eu
<i>Carabus variolosus nodulosus</i> Creutzer 1799	VU	c, e – Eu
<i>Carabus violaceus</i> Linné 1758		Eu
<i>Cychrus attenuatus</i> (Fabricius 1792)		Eu
<i>Harpalus affinis</i> (Schrank 1781)		ES
<i>Harpalus dimidiatus</i> (Rossi 1790)		e – Eu, Turan
<i>Laemostenus elongatus</i> (Dejean, 1828)		Alb, B&H, CR, It, Slo,Srb, Mtn, Kos
<i>Leistus rufomarginatus</i> (Duftschmid 1812)		Eu, Cauc
<i>Leistus spinibarbis</i> (Fabricius 1775)		Eu - Med

Table 3. continued

Tablica 3. Nastavak

Species (Učka 2008)	Croatian Red List of ground beetles	Zoogeographical region
<i>Licinus hoffmannseggi</i> (Panzer 1797)	NT	z, se – E
<i>Molops ovipennis</i> Chaudoir 1847	NT	se – Alp
<i>Molops piceus</i> (Panzer 1793)	NT	c – Eu
<i>Molops striolatus</i> (Fabricius 1801)		se – Eu
<i>Myas chalybaeus</i> (Palliard 1825)	VU	Balk
<i>Nebria brevicollis</i> (Fabricius 1972)		w – Pal
<i>Nebria dahlii</i> (Duftschmid 1812)	NT	e – Alp, se – Eu
<i>Notiophilus biguttatus</i> (Fabricius 1779)		w – ES
<i>Notiophilus palustris</i> (Duftschmid 1812)		c – ES
<i>Notiophilus rufipes</i> Curtis 1829		Eu, Cauc
<i>Poecilus koyi lossinianus</i> Fairmaire 1860	VU	sw c-E , CR
<i>Pseudoophonus rufipes</i> (De Geer 1774)		ES, Med, w – Chin
<i>Pterostichus burmeisteri</i> Heer 1838		c – Eu
<i>Stomis rostratus</i> (Duftschmid 1812)		ES

## Conclusions

The specific position of Mt Učka between two geographical regions is reflected on species structure with respect to zoogeographical distribution, which as a consequence results in the high biodiversity of this area. One quarter of the collected species is listed in the Croatian Red list of ground beetles including seven endemic, mostly alpine species. Higher altitude areas of Mt Učka should be particularly taken in concern in formulating nature protection strategies, especially the forest community of altimontane beech forests with coltsfoot (*Homogyno alpinae-Fagetum*) due to the large number of collected endangered species that are threatened by potential reduction in range as a result of climate changes in the future.

## Acknowledgements

We would like to thank the Učka Nature Park for field work assistance. We are most grateful to Dr Sven Jelaska for help in the selection of the forest communities. Finally, we wish to thank the anonymous reviewers for the constructive comments and suggestions on an earlier version of the manuscript.

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