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CADDISFLY (INSECTA: TRICHOPTERA) FAUNA OF PAPUK NATURE PARK, CROATIA

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Adult caddisflies were collected in early summer and autumn in 2012 at various freshwater habitats within Papuk Nature Park. Caddisflies were collected using sweep nets and light traps at eight sampling sites. A total of 360 individuals belonging to 33 species, 24 genera and 11 families were recorded during the current study. A preliminary list of caddisfly species occurring in Papuk Nature Park is presented. Seven species collected are the first records for the caddisfly fauna of Croatia: *Rhyacophila loxias*, *Rhyacophila nubila*, *Rhyacophila obliterata*, *Rhyacophila polonica*, *Wormaldia pulla*, *Diplectrona atra* and *Drusus schmidi*. Some of these species were also hitherto not recorded within the ecoregion Hungarian lowlands (ER11). Additionally, the rare *Beraea maurus* was recorded for the first time in Croatia after the single finding in 1934.

Keywords: caddisfly distribution, *Drusus schmidi, Rhyacophila, Wormaldia pulla, Diplectrona atra*

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Odrasli tulari prikupljani su u rano ljeto i jesen 2012. godine na različitim slatkovodnim staništima u Parku prirode Papuk. Istraživanjem je obuhvaćeno osam različitih postaja, a prikupljanje je provedeno uz pomoć entomoloških mrežica i svjetlosnih klopki. Ukupno je prikupljeno 360 jedinki iz 33 vrste, 24 roda i 11 porodica tulara. U radu je prikazan preliminarni popis faune tulara Parka prirode Papuk. Sedam vrsta zabilježenih u ovom istraživanju novo je za faunu Hrvatske: *Rhyacophila loxias*, *Rhyacophila nubila*, *Rhyacophila obliterata*, *Rhyacophila polonica*, *Wormaldia pulla*, *Diplectrona atra* i *Drusus schmidi*. Osim toga, neke od tih vrsta do sada nisu bile zabilježene niti u panonskoj limnoregiji (ekoregija ER11). Nadalje, zanimljiv je i nalaz rijetke vrste *Beraea maurus* koja je u Hrvatskoj do sada zabilježena samo s jednim primjerkom 1934. godine.

Ključne riječi: rasprostranjenost tulara, *Drusus schmidi, Rhyacophila, Wormaldia pulla, Diplectrona atra*

INTRODUCTION

Communities of aquatic invertebrates are widely used in environmental quality assessment and monitoring of freshwater ecosystems (e.g. Hering *et al*., 2006). Caddisflies (Trichoptera) are one of the groups of aquatic insects that represent ideal bioindicator models. Their use in such practice already has a long tradition in many countries (e.g. Dohet, 2002; Graf *et al*., 2008; Moog, 2002). In order to establish a solid background for any kind of assessment activities, good knowledge of the caddisfly community composition and structure of particular regions is necessary (e.g. Hering *et al*., 2006; Moog, 2002). The essential first step towards gaining such knowledge is obtaining faunistic data of this and other aquatic insect groups (e.g. Popijač & Sivec, 2011; Previšić *et al*., 2010; Vilenica *et al*., 2011).

The Papuk Mountains area, a hilly area within the agricultural lowland region, is under national protection (Nature Park) since 1999 (www.papukgeopark.com). Since it

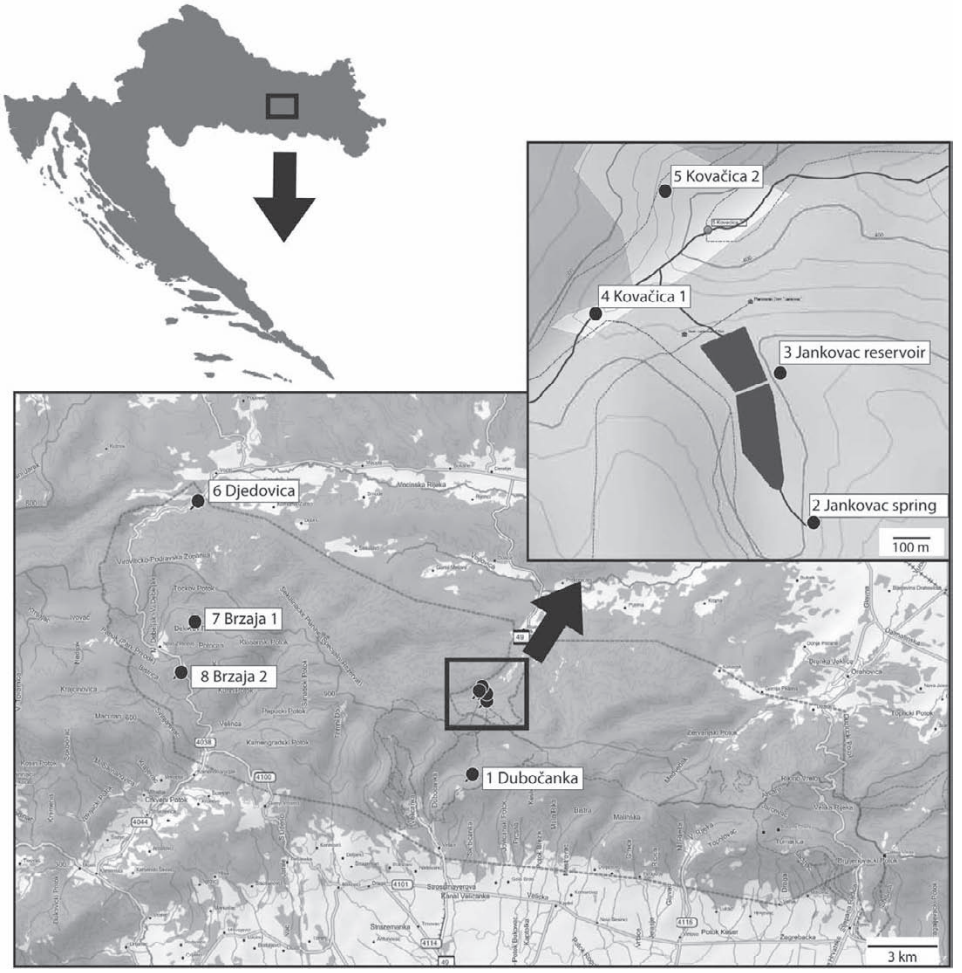

Fig. 1. Map of the study area showing the location of sampling sites in the Papuk Nature Park. Inset shows enlarged area with geographically proximate sites.

represents a geologically unique area regarding the age and diversity of rocks (e.g. Jamičić, 1983; 2003), in 2007 it became a member of the European and UNESCO Global Geopark Network (www.papukgeopark.com). The Papuk Mountains are mostly covered with forests and there are many different types of forest associations present in the area (Pandža, 2010). The area harbours a large network of streams and a variety of different freshwater habitats (e.g. Kuhta & Brkić, 2003; Petrović, 1969). Vertebrate fauna of the Papuk Mountains is generally much better explored than the invertebrate fauna, including freshwater species (e.g. Mrakovčić *et al.*, 2008). However, an endemic snail species was described from the spring of the Jankovac stream (i.e. *Graziana papukensis* Radoman 1975; Jalžić & Leitner, 2011). More recent studies provide data on zooplankton (Špoljar *et al.*, 2012a), meiofauna and macroinvertebrate communities of the karstic Jankovac stream and associated reservoirs (Špoljar *et al.*, 2012b), and Djedovica and Dubočanka

streams (Kerovec *et al.*, 2011). However, hitherto not a single group of aquatic insects was systematically surveyed within this region.

Therefore, the aim of this study was to 1) gain a first insight into the faunistic composition of the caddisflies of Papuk Nature Park, 2) document the composition of caddisfly communities in different habitat types within the Papuk NP (springs, streams and reservoirs).

METHODS

Sampling of caddisflies

We collected adult caddisflies in early summer (13th and 14th June 2012) and autumn (18th and 19th September 2012) at eight sampling sites within Papuk Nature Park (Fig. 1). Selected sampling sites encompassed various habitats, i.e. a spring, a reservoir and six stream sites (Fig. 2). In addition to collecting caddisflies, we measured some physico-chemical properties of the water *in situ*; the pH value (using the WTW pH 330 pH-meter), the concentration and saturation of dissolved oxygen (using the WTW Oxi 330/SET), the carbonate hardness (Höll, 1986) and the conductivity (using the WTW LF 330 conductometer). Details on geographic position, habitat type, geology, physico-chemical properties of the water, etc. of all sampling sites are presented in Tab. 1.

Caddisflies were collected using sweep nets and light traps (Tab. 1). The light trap used was an 8 W ultraviolet (UV) fluorescent tube powered by a 12 V battery, operated at selected sites for at least one hour. Collected material was preserved in 80 % ethanol. Identification was based on Malicky (2004) and Neu & Tobias (2004) and systematic review on Malicky (2005).

RESULTS AND DISCUSSION

Caddisfly fauna of Papuk NP – new records for Croatian fauna & notes on distribution

A total of 360 individuals, belonging to 33 species (38 taxa; including the females that were identified to the genus level), 24 genera and 11 families were recorded during the current study (Tab. 2). Overall, Limnephilidae was the most diverse family, represented with eleven species belonging to eight genera, followed by Rhyacophilidae represented by seven species. The other families were represented with one to four different species each (Tab. 2). It was not possible to identify the females of some genera to the species level with certainty (etc. *Glossosoma, Hydropsyche, Crunoecia* etc.), hence these data are presented at the genus level only.

In this study the following seven species are first records for the caddisfly fauna of Croatia: *Rhyacophila loxias* Schmid, 1970, *Rhyacophila nubila* (Zetterstedt, 1840), *Rhyacophila obliterata* McLachlan, 1863, *Rhyacophila polonica* McLachlan, 1879, *Wormaldia pulla* (McLachlan, 1878), *Diplectrona atra* McLachlan, 1878 and *Drusus schmidi* Botosaneanu, 1960 (Ćuk & Vučković, 2009; 2010; Graf & Schmidt-Kloiber, 2011; Kučinić *et al.*, 2011; 2012; Malicky 2009; Marinković-Gospodnetić, 1979; Previšić *et al.*, 2007; 2010; Radovanović 1935). Moreover, records of *R. loxias, R. obliterata, W. pulla, D. atra* and *D. schmidi* represent first data on distribution of these species in the ecoregion Hungarian lowlands (ER11, Illies, 1978) (Graf *et al.*, 2008, Graf & Schmidt-Kloiber, 2011).

Tab 1. Eight sampling sites in the Papuk Nature Park where caddisflies were collected in 2012. J/S: J denotes the first collecting trip (June) and S the second collecting trip (September); Kovačica 1 and Kovačica 2 were sampled only in June and September, respectively. Methods used for caddisflies collecting; sn - sweep net, lt – light trap.

Site	(1) Dubočanka	(2) Jankovac spring	(3) Jankovac reservoir	(4) Kovačica 1	(5) Kovačica 2	(6) Djedovica	(7) Brzaja 1	(8) Brzaja 2
Elevation (m)	451	544	505	468	418	270	714	420
Latitude	N 45 29 12.0	N 45 31 06.9	N 45 31 14.9	N 45 31 20.9	N 45 31 26.4	N 45 36 17.4	N 45 33 11.7	N 45 31 52.4
Longitude	E 17 40 43.1	E 17 41 14.7	E 17 41 10.8	E 17 40 56.9	E 17 41 06.0	E 17 31 54.8	E 17 31 51.9	E 17 31 25.3
Habitat type	stream	spring	reservoir	stream	stream	stream	stream	stream
Geologic substrate*	carbonate	carbonate	carbonate	carbonate	carbonate	magmatic	magmatic	magmatic
Substrate composition	stones, gravel, sand moss	stones, gravel, sand, tufa moss	sand macrophyte	stones, gravel, sand	stones, gravel, sand moss	stones, gravel, sand moss	stones, gravel, sand	stones, gravel, sand
Surrounding vegetation	beech forest	beech forest	beech forest	beech forest	beech forest	beech forest	beech forest	beech forest
Riparian canopy	closed	closed	open	open	closed	open	closed	open
Water temperature (°C) J/S	13.5 / 14.7	9.3 / 10	19.4 / 13.7	13.2	14.2	15.2 / 16.1	13 / 14.9	13.4 / 14
Oxygen (mg/l) J/S	9.85 / 9.93	12.32 / 10.16	11.7 / 9.89	11.2	9.94	9.95 / 9.22	10.63 / 8.97	12.1 / 8.93
Oxygen saturation (%) J/S	100 / 102.3	113.7 / 95.8	131 / 101	112	101.5	101 / 96.2	106 / 94	121 / 90.5

Site	(1) Dubočanka	(2) Jankovac spring	(3) Jankovac reservoir	(4) Kovačica 1	(5) Kovačica 2	(6) Djedovica	(7) Brzaja 1	(8) Brzaja 2
Conductivity (µS/cm) J/S	307 / 381	487 / 485	442 / 422	322	397	150 / 204	66 / 74	100 / 113
pH J/S	8.22 / 8.43	7.52 / 7.87	7.87 / 8.01	8.3	8.35	7.58 / 7.94	6.95 / 7.64	7.5 / 7.75
Carbonate hardness (d°H) J/S	155 / 180	255 / 255	240 / 225	160	215	55 / 80	20 / 30	40 / 40
Methods J/S	sn / sn, lt	sn, lt / sn, lt	sn, lt / sn, lt	sn	sn	sn / sn, lt	sn, lt / sn, lt	sn

*According to Pamić *et al.*, 2003.

The distribution range of *R. loxias* covers large part of the Balkan Peninsula, including the neighbouring Bosnia & Herzegovina (Stanić-Koštroman, 2009), however it was hitherto not recorded north of the ecoregion Dinaric Western Balkan (ER5; Illies, 1978) (Graf *et al.*, 2008; Graf & Schmidt-Kloiber, 2011). The area of Papuk NP is thus the northern border of the distribution range of *R. loxias*. The distribution range of *R. nubila* covers large parts of Europe, whereas the distribution range of *R. polonica* covers Central Europe and the Balkan Peninsula, (Graf *et al.*, 2008, Graf & Schmidt-Kloiber, 2011). However, no records have been published for Croatia (Ćuk & Vučković, 2009; 2010; Graf & Schmidt-Kloiber, 2011; Kučinić *et al.*, 2011; 2012; Malicky 2009; Marinković-Gospodnetić, 1979; Previšić *et al.*, 2007; 2010; Radovanović, 1935). *R. obliterata* and *W. pulla* are distributed over large parts of Europe, yet our records represent the first data on the distribution of these species in the ER11 (Graf *et al.*, 2008, Graf & Schmidt-Kloiber, 2011). Similarly, *D. atra* was not recorded within the ER11. Its range was previously confined to the Alps and ecoregions south of the Alps (i.e. from the Apennine Peninsula to the Middle East; Graf *et al.*, 2008, Graf & Schmidt-Kloiber, 2011). *D. schmidi* was endemic to the ER5 (Graf & Schmidt-Kloiber, 2011; Previšić *et al.*, 2009; Stanić-Koštroman, 2009) and the northernmost known distribution point was in Central Bosnia (Kreševka River; Stanić-Koštroman, 2009). Additionally, it was the most abundant species in this study, with a total of 52 specimens collected at Dubočanka (Tab. 2). The majority of *Drusus* species are coldwater stenotherms inhabiting springs and headwater streams (e.g. Graf *et al.*, 2008). However, the water temperature of this stream was higher than 10°C on both occasions (Tab. 1) providing valuable information on the ecology of this species.

In addition to the new records, the finding of *Beraea maurus* (Curtis, 1834) is also valuable faunistic data. Distribution of this rare species covers most of Europe (Graf & Schmidt-Kloiber, 2011), but only a single male was previously collected in Croatia, in 1934 in the surroundings of Lepoglava (Malicky, 2009).

Fig. 2. Different freshwater habitats in the Papuk Nature Park where caddisflies were collected in 2012: a) Dubočanka, b) Jankovac spring, c) Jankovac reservoir, d) Kovačica 1, e) Kovačica 2, f) Djedovica, g) Brzaja 1, h) Brzaja 2.

Tab. 2. List of caddisfly species collected at eight sites in 2012 in the Papuk Nature Park. For the abbreviations of the sampling sites see Tab. 1. (m – males, f – females, * only females collected, ** records from Oláh 2010, ◆ new record for caddisfly fauna of Croatia).

Sites	1		2		3		4		5		6		7		8	
Species	m	f	m	f	m	f	m	f	m	f	m	f	m	f	m	f
Rhyacophilidae																
Rhyacophila fasciata Hagen, 1859	7	4							1			1			6	4
◆*Rhyacophila loxias* Schmid, 1970	5	2														1
◆*Rhyacophila nubila* (Zetterstedt, 1840)															1	1
◆*Rhyacophila obliterata* McLachlan, 1863					1				2							
◆*Rhyacophila polonica* McLachlan, 1879	1		1													
Rhyacophila schmidinarica Urbanič, Krušnik & Malicky, 2000			1													
Rhyacophila tristis Pictet, 1834	7	6	1	2			3								2	1
Glossosomatidae																
Glossosoma conformis Neboiss, 1963															1	
**Glossosoma* sp.		6								2		1				52
Agapetus ochripes Curtis, 1834	1															
Philopotamidae																
Philopotamus montanus (Donovan, 1813)	14	8											2			
Philopotamus variegatus (Scopoli, 1763)											2					
**Philopotamus* sp.				1				1								1
Wormaldia occipitalis (Pictet, 1834)			3	1			1									

Sites	1		2		3		4		5		6		7		8	
Species	m	f	m	f	m	f	m	f	m	f	m	f	m	f	m	f
◆*Wormaldia pulla* (McLachlan, 1878)							1									
**Wormaldia* sp.				1				1								
Hydropsychidae																
◆*Diplectrona atra* McLachlan, 1878	5															
Hydropsyche instabilis (Curtis, 1834)	5		1		1											
Hydropsychidae non det.		13		2		4										1
Polycentropodidae																
***Plectrocnemia conspersa* (Curtis, 1834)	+															
Psychomyiidae																
Lype reducta (Hagen, 1868)	2		2						3				4		1	
Tinodes rostocki McLachlan, 1877	1	1	4	5				1		2						1
Limnephilidae																
Anabolia furcata Brauer, 1857			2		1											
◆*Drusus schmidi* Botosaneanu, 1960	9	43	1													
***Chaetopteryx papukensis* Oláh & Szivák, 2012	+															
Glyphotaelius pellucidus (Retzius, 1783)			3	1	1											
Halesus digitatus (Schrank, 1781)	1															
Limnephilus lunatus Curtis, 1834			5		3											

Sites	1		2		3		4		5		6		7		8	
Species	m	f	m	f	m	f	m	f	m	f	m	f	m	f	m	f
Limnephilus rhombicus (Linnaeus, 1758)			1	4												
Micropterna sequax (McLachlan, 1875)	1	3	1		2											
Potamophylax latipennis (Curtis, 1834)	2	11	2								1		2		2	1
**Potamophylax* sp.				1		2										4
Stenophylax permistus McLachlan, 1895			3													
Goeridae																
Silo piceus (Brauer, 1857)		2														
Lepidostomatidae																
**Crunoecia* sp.										1						
Leptoceridae																
Athripsodes aterrimus (Stephens, 1836)			1		16	2										
Mystacides azurea (Linnaeus, 1761)															1	
Sericostomatidae																
Sericostoma personatum Kirby & Spencer, 1826	1										1					
Beraeidae																
Beraea maurus (Curtis, 1834)									1							
Ernodes articularis (Pictet, 1834)	1															
Total number of species	19		22		9		6		7		5		3		13	
Total number of specimens	162		75		33		8		12		6		8		90	

Two additional species were previously recorded within Papuk NP (Oláh, 2010) and these were thus included in the species inventory of the NP (Tab. 2). Taxonomic status of the specimens collected at the Jankovac spring in 2007, previously reported as *Chaetopteryx rugulosa mecsekensis* Nógrádi, 1986 (Oláh, 2010) has changed recently. Thus, the Jankovac spring is a type locality of a new species, *Chaetopteryx papukensis* Oláh & Szivák, 2012 (Oláh *et al.*, 2012). The species was later collected at further localities in the Papuk NP (e.g. Kovačica River, Oláh *et al*., 2012).

The majority of caddisfly species recorded in this study have wide distributions in Europe, although some are confined to Central Europe (e.g., *Anabolia furcata* Brauer, 1857; etc. Graf & Schmidt-Kloiber, 2011).

Overall, considering faunistic data, ecology and distribution patterns of the caddisfly species recorded in this study, composition of caddisfly fauna of Papuk NP is exceptionally interesting and a further, systematic survey is necessary. Similar to other montane areas in Croatia, where isolated springs have acted as microrefugia for coldwater stenotherm stoneflies (Popijač & Sivec, 2009) and caddisflies (Previšić & Popijač, 2010; Previšić *et al.*, 2009), this area is most likely also a refugial region for aquatic insects. The interplay of the specific geographic position, geological events and a variety of isolated freshwater habitats in the Papuk Mountains (e.g. springs and streams) has resulted in a unique composition of caddisfly fauna.

Composition of caddisfly communities in different habitats in Papuk NP

The majority of species recorded in this study were collected at a single site or at two sites, and only three species were collected at a total of five collecting sites (Tab. 2). In addition to collecting effort having been insufficient to encompass a full species inventory, the ecology of particular species is also important (e.g. their habitat preferences, Moog, 2002). For instance, species collected at five (*Lype reducta* (Hagen, 1868), *Potamophylax latipennis* (Curtis, 1834); Tab. 2) or four different sites (*Rhyacophila fasciata* Hagen, 1859, *Rhyacophila tristis* Pictet, 1834; Tab. 2) typically occur from springs to potamal sections of rivers (Graf & Schmidt-Kloiber, 2011). By contrast, some species are limited to specific habitat types or particular zones of running water, e.g. *Rhyacophila schmidinarica* Urbanič, Krušnik & Malicky, 2000 occurring exclusively in crenal sections (Graf & Schmidt-Kloiber, 2011).

The highest number of caddisfly taxa were recorded at the Jankovac spring, followed by the site at Dubočanka (Tab. 2). Considering the use of light traps in the current study, it is not a surprise that highest number of taxa were collected at the Jankovac spring. In the close vicinity of the spring area several different freshwater habitats are present (streams, reservoirs) and light traps can attract specimens even from large distances (e.g. Malicky, 1987). Moreover, in order to gain a more detailed insight into the caddisfly communities of selected habitats a variety of methods through a longer sampling period should be employed (e.g. Previšić *et al.*, 2010).

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SAŽETAK

Fauna tulara (Insecta: Trichoptera) Parka prirode Papuk, Hrvatska

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Područje Papuka zaštićeno je kao Park prirode od 1999. godine, a od 2007. godine ima status Geoparka (pod zaštitom UNESCO-a). Unatoč velikoj geološkoj i biološkoj raznolikosti te bogatstvu slatkovodnih staništa, niti jedna skupina vodenih kukaca nije do sada sustavno istraživana na području Papuka. Cilj ovog istraživanja bio je dati prvi pregled sastava faune tulara (Insecta: Trichoptera) na području Parka prirode Papuk.

Odrasli tulari prikupljani su dva puta, u rano ljeto i jesen 2012. godine na različitim slatkovodnim staništima u Parku prirode Papuk. Istraživanjem je obuhvaćeno osam različitih postaja (izvor, potoci i akumulacija), a prikupljanje je provedeno uz pomoć entomoloških mrežica i svjetlosnih klopki. Ukupno je prikupljeno 360 jedinki iz 33 vrste, 24 roda i 11 po-

rodica tulara. Sedam vrsta zabilježenih u ovom istraživanju novo je za faunu Hrvatske: *Rhyacophila loxias, Rhyacophila nubila, Rhyacophila obliterata, Rhyacophila polonica, Wormaldia pulla, Diplectrona atra* i *Drusus schmidi*. Osim toga, neke od tih vrsta (*R. loxias, R. obliterata, W. pulla, D. atra* and *D. schmidi*) do sada nisu bile zabilježene niti u panonskoj limnoregiji (ekoregija ER11) te ovi nalazi predstavljaju nove podatke o njihovim arealima. Nadalje, zanimljiv je i nalaz rijetke vrste *Beraea maurus* koja je u Hrvatskoj do sada zabilježena samo s jednim primjerkom 1934. godine u okolici Lepoglave.

Obzirom na preliminarne podatke o fauni tulara i bogatstvo različitih slatkovodnih staništa na području PP Papuk, očekujemo da će buduća istraživanja zabilježiti znatno veći broj vrsta ove skupine te još faunistički zanimljivih nalaza među vodenim kukcima.