

THE GENUS *ECCLISOPTERYX* (INSECTA: TRICHOPTERA: LIMNEPHILIDAE) IN CROATIA: DISTRIBUTION AND CONSERVATION ASPECTS

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This paper presents the distribution of two species of the genus *Ecclisopteryx* in Croatia based on literature data and the new records: *E. keroveci* and *E. ivkae*. The species *E. ivkae* was recorded at eight sites in the catchment area of the Cetina River, while *E. keroveci* occurs within the catchment area of the Kupa River and along the Veličanka River. Due to the restricted distribution, we proposed conservation and protection measures for both species.

Key words: *Ecclisopteryx keroveci*, *Ecclisopteryx ivkae*, new records

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U ovom radu je prikazana rasprostranjenost dviju vrsta roda *Ecclisopteryx* u Hrvatskoj: *E. keroveci* i *E. ivkae*, na osnovu literaturnih podataka i novih nalaza. Vrsta *E. ivkae* zabilježena je na slivnom području rijeke Cetine, a vrsta *E. keroveci* na slivnom području Kupe i rijeci Veličanki. U radu su predložene i mjere zaštite za obje vrste, a odnose se na zaštitu kako samih vrsta tako i staništa na kojem obitavaju.

Ključne riječi: *Ecclisopteryx keroveci*, *Ecclisopteryx ivkae*, novi nalazi

INTRODUCTION

The genus *Ecclisopteryx* Kolenati, 1848 (subfamily Drusinae; family Limnephilidae) is currently represented by seven species in Europe and two species in the Asian part of Turkey (MALICKY, 2004; PREVIŠIĆ *et al.*, 2014; SIPAHILER, 2015). In Europe *E. dalecarlica* Kolenati, 1848, *E. madida* (McLachlan, 1867) and *E. guttulata* (Pictet, 1834) are relatively widely distributed species occurring in several ecoregions according to ILLIES, 1978 with partially overlapping ranges (GRAF *et al.*, 2008; GRAF & SCHMIDT-KLOIBER, 2011). The following two species are endemic with a limited distribution in the Alps: *E. asterix*, Ma-

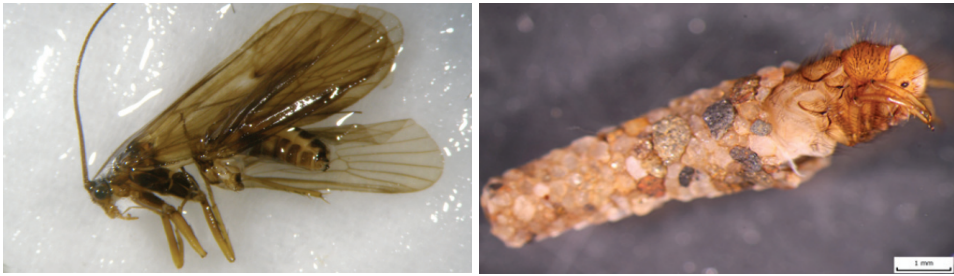


Fig. 1. *E. keroveci*, a) adult; b) larva



Fig. 2. *E. ivkae*, a) adult; b) larva

licky, 1979 occurs in the Karawanken and Julian Alps while the species *E. malickyi* Moretti, 1991 inhabits the Lessinian Alps (GRAF *et al.*, 2008, 2011; GRAF & SCHMIDT –KLOIBER, 2011). The adults of five European species *E. madida*, *E. asterix*, *E. malickyi*, *E. dalecarlica* and *E. guttulata* are morphologically well separated as larva and adults (MALICKY, 2004; WARINGER & GRAF, 2011; PREVIŠIĆ *et al.*, 2014). Recently, two new species from the Western Balkans have been described, based on the results of DNA sequence analysis and morphological features: *E. keroveci* Previšić, Graf & Vitecek, 2014 from the type locality at the mouth of the Jabučica River in Sutjeska National park (Bosnia and Herzegovina) (Fig. 1a and 1b) and *E. ivkae* Previšić, Graf & Vitecek, 2014 from the type locality at the Glavaš spring of the Cetina River (Croatia) (Fig. 2a and 2b) (PREVIŠIĆ *et al.*, 2014). Both of these species are closely related to *E. dalecarlica* and can be readily identified in both adult and larval stages (PREVIŠIĆ *et al.*, 2014). Due to these new descriptions, it is now recognized that *E. keroveci* from Western Balkans was formerly misidentified as *E. dalecarlica* in Croatia (PREVIŠIĆ & POPIJAČ, 2010, VUČKOVIĆ, 2011, VUČKOVIĆ *et al.*, 2011), Bosnia and Herzegovina (STANIĆ-KOŠTROMAN *et al.*, 2015) and Montenegro (OLÁH & KOVÁCS, 2014). One faunistic data of *E. keroveci* from Kosovo (IBRAHIMI, 2104) was corrected and supplemented with new finding of this species in paper IBRAHIMI *et al.* (2015). OLÁH & KOVÁCS (2014) found *E. keroveci* in Republic of Macedonia for the first time at two localities, Šarmountain and Vevčani spring (KUČINIĆ *et al.*, 2016). The literature data of RADOVANOVIĆ (1935) and MARINKOVIĆ-GOSPODNETIĆ (1970) for the species *E. guttulata* in Bosnia and Herzegovina was probably falsely determined.

The latest study by SIPAHILER, 2015 reports two new *Ecclisopteryx* species from Turkey: *E. oylat* from Bursa Province in the Marmara Region and *E. aksu* from Isparta Province in southern Turkey. Both new species are morphologically most similar and potentially

Tab. 1. Localities of *Ecclisopteryx* in Croatia with short-codes, stage, ecoregion and date of the record (*literature data). The short-codes correspond to those in Figs 4 and 5; Lv. – Larva, Ad. – Adult

short-code	Locality	Stage	Ecoregion	Date
<i>Ecclisopteryx keroveci</i>				
1.	The Čabranka River – spring*	Ad.	ER 5	May 2013
2.	The Čabranka River –mouth	Lv., Ad.	ER 5	Stage Lv., May 2013, Stage Ad., May 2015
3.	The Kupa River – Brod na Kupu	Ad.	ER 5	May 2015
4.	The Kupa River – after the confluence with the Čedanĳ River	Lv.	ER 5	October 2013
5.	The Kupa River – before the confluence with the Čabranka River*	Lv.	ER 5	May 2013
6.	The Kupica River – mouth	Lv.	ER 5	October 2013
7.	The Belica River – bridge at Kuželj*	Ad.	ER 5	July 2012
8.	The Dretulja River – Plaški, upper reach	Ad.	ER 5	May 2015
9.	The Curak stream – mouth	Lv.	ER 5	May 2013
10.	The Veličanka River – upper reach	Ad.	ER 11	May 2015
<i>Ecclisopteryx ivokae</i>				
11.	The Cetina River – Glavaš spring*	Lv.	ER 5	Stage Lv., November 2014 Stage Ad., May, July 2005, 2007, 2012
12.	The Cetina River – Vukovića spring	Lv.	ER 5	February 2015
13.	The Nele spring	Lv.	ER 5	February 2015
14.	The Batice spring	Lv.	ER 5	February 2015
15.	The Cetina River – Red bridge*	Lv.	ER 5	February 2015
16.	The Cetina River -Vinalić*	Lv.	ER 5	February 2015
17.	The Rumin River – Rumin Veliki spring	Lv.	ER 5	February 2015
18.	The Rumin River – Rumin Mali spring	Lv.	ER 5	February 2015

closely related to *E. dalecarlica* (SİPAHİLER, 2015). The larvae of species *E. oylat* and *E. aksu* have not been described.

This paper presents detailed distribution data on the genus *Ecclisopteryx* in Croatia and new observations on the ecology of both species *E. keroveci* and *E. ivokae*. Additionally, some conservation aspects for these species and their features habitats are discussed.

MATERIAL & METHODS

Research area

Adults and larvae of the genus *Ecclisopteryx*, were collected by several rivers in Croatia. Most of the records originate from the Kupa and Cetina catchment area (Ecoregion

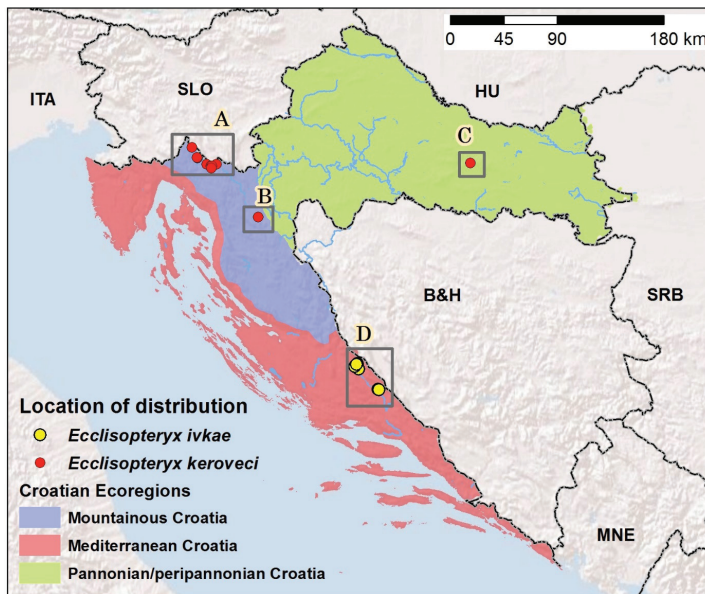


Fig. 3. Distribution of *Ecclisopteryx* species in Croatia

5 (ER 5) – Dinaric Western Balkan), while one record originates from the Veličanka River at Mt. Papuk (Ecoregion 11 (ER 11) – Hungarian lowlands) (ILLIES, 1978) (Fig. 3, Tab. 1). Records in the Kupa catchment area include the upper course of the Kupa River as well as its tributaries, the Kupica, the Čabranka, the Belica and the Curak rivers. The Kupa catchment area covers 10,236 km², 8,412 km² of which is in Croatia (NARODNE NOVINE, 2008). The length of the Kupa River is 294 km; its spring is located in Kupari village while the mouth into the Sava River is at Sisak. The upper course of the Kupa River, the Čabranka, the Kupica and the Dretulja rivers are classified as „Medium and large montane and upland rivers” (HR-R_7), while the Belica and the Curak rivers are classified as „Small mountainous and upland streams” (HR-R_6) (NARODNE NOVINE, 2013, 2014). The Dretulja River is a tributary of the Mrežnica River and is classified as „Medium and large mountainous and upland river” (HR-R_7) while the Veličanka River belongs to the „small lowland rivers with gravel and pebble substrate” (HR-R_2B) river type (NARODNE NOVINE, 2013, 2014).

The Cetina River catchment covers 4,145 km², 1,531 km² of which is in Croatia (NARODNE NOVINE, 2008). The length of the Cetina River is 104 km, with the main spring situated at Glavaš while the mouth into Adriatic Sea is at Omiš. The upper course of the Cetina River is classified as a „Medium and large upland rivers” (HR-R_12) (NARODNE NOVINE, 2013, 2014). The Rumin is a small left tributary of the Cetina River; its total length is 1,4 km.

Sampling and laboratory work

The data in this study originate from the following sources: 1) the EU Natura 2000 Integration Project (NIP) project in which adult caddisflies were sampled at 105 localities all over Croatia in the period from 2014 to 2015; 2) individual research; 3) the regular

monitoring of surface water quality in which caddisfly larvae are sampled as part of benthic macroinvertebrates (unpublished data of Hrvatske vode); 4) literature data (PREVIŠIĆ *et al.*, 2014; OLÁH & KOVÁCS, 2014; STANIĆ-KOŠTROMAN *et al.*, 2015; IBRAHIMI *et al.*, 2014, 2015; KUČINIĆ *et al.*, 2016).

Most of the adult caddisfly specimens were collected during 2014 and 2015 by light trapping, using 6 W or 8 W ultraviolet (UV) fluorescent tubes powered by a 12 V battery. Larvae were collected by hand-net with a mesh size of 500 µm and by handpicking.

The collected material was preserved and stored in 96% ethanol. Adult specimens are deposited in the Croatian Natural History Museum in Zagreb in the collection NIP – Trichoptera while larvae are deposited in the Central Water Management Laboratory of Hrvatske vode. Macrophotographing of larvae and adults was done at the Faculty of Forestry, University of Zagreb (using a Leica Wild MZ8 stereomicroscope and Olympus SP-500 UZ digital camera) and Central Water Management Laboratory of Hrvatske vode (using stereomicroscope SZX10 and Canon EOS 1100D STL digital camera) processed with the computer program Olympus Quick Photo Camera.

The physico-chemical parameters of water from most sampling stations (for the year of 2013) were provided by Hrvatske vode and include water temperature (°C), dissolved oxygen (mg O₂/l), oxygen saturation (%), conductivity (µS/cm), pH, alkalinity (mg CaCO₃/l), COD (mg O₂/l), BOD₅ (mg O₂/l), ammonia (mg N/l), nitrites (mg N/l), total nitrogen (mg N/l), orthophosphates (mg P/l) and total phosphorus (mg P/l). Two sampling stations (Nele Spring, Rumin – Veliki Rumin Spring) are not covered by national water quality monitoring and therefore the physico-chemical parameters were taken from a previous study by VUČKOVIĆ, 2011.

RESULTS & DISCUSSION

Distribution

All hitherto known records of *E. keroveci* and *E. ivkae* from Croatia are presented in Tab. 1 and (Fig. 3).

E. keroveci has a disjunct distribution from the Slovenian-Croatian border, through Bosnia and Herzegovina, Montenegro and Kosovo to Macedonia (PREVIŠIĆ *et al.*, 2009; PREVIŠIĆ & POPIJAČ, 2010, VUČKOVIĆ, 2011, VUČKOVIĆ *et al.*, 2011; OLÁH & KOVÁCS, 2014, IBRAHIMI, 2014, IBRAHIMI, 2015; STANIĆ-KOŠTROMAN *et al.*, 2015) (Fig. 6) and is considered endemic for the ER 5 (PREVIŠIĆ *et al.*, 2014).

In Croatia, former studies recorded the species in a small area in Gorski kotar at three localities in ER5 (according to ILLIES, 1978), or in Central-mountain area (BERTIĆ *et al.*, 2001) (Fig. 3). Our research increased the records of five new localities in the Central-mountain area (The Čabranka River – mouth, The Kupa River – Brod na Kupi, The Kupa River – after the confluence with the Čedanjan River, The Kupica River – mouth The Curak stream – mouth), one records in Ogulin-Plaški submountain valley (The Dretulja River – Plaški, upper reach) which are situated in ER5. The locality at the Veličanka River – upper reach is in ER11 (according to ILLIES, 1978) and in the Pannonian-Peripannonian region (BERTIĆ *et al.*, 2001) (Fig. 3, 4), which represents the first finding of this species outside the ER5. Such a pattern of disjunctive distribution is not unusual within the subfamily Drusinae and is a consequence of the ecological demands of these species as well as geological and hydrological processes in the past (PREVIŠIĆ *et al.*, 2014). A similar distribution is found in case of e.g., *Drusus schmidi* (PREVIŠIĆ *et al.*, 2013; KUČINIĆ *et al.*, 2014).

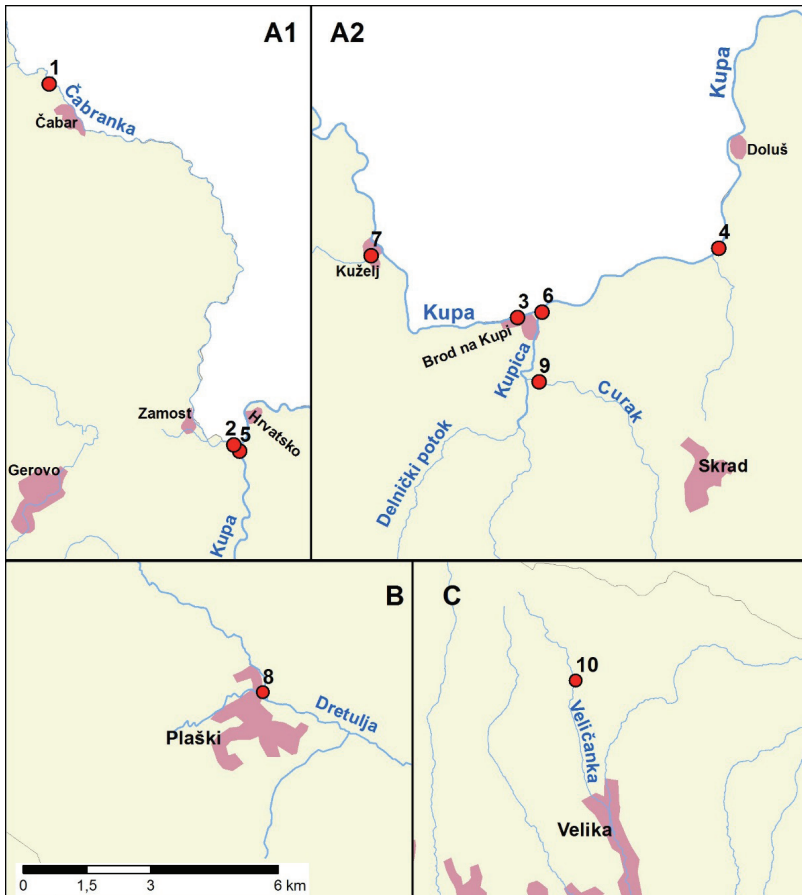


Fig. 4. Distribution of *E. keroveci* in the Kupa, the Čabranka, the Curak and the Kupica rivers (detail A of the Fig. 4) in the Dretulja (detail B of the Fig. 4) and the Veličaka River (detail C of the Fig. 4)

On the other hand *E. ivkae* is a microendemic species restricted to a few springs and spring areas in the catchment area of the Cetina River (Fig. 3, 5). This study presents new records from springs of the Cetina River but also from its tributary, the Rumin River. With the new findings areal for *E. ivkae* was extended about 20 km to the south. Such a localized distribution is confirmed by several recent faunistic studies that did not recover the species in any other part of the country. The detailed studies of MARINKOVIĆ-GOSPODNETIĆ (1978, 1979) and STANIĆ-KOŠTROMAN *et al.*, 2012 do not list any species from the genus *Ecclisopteryx* in the western parts of Bosnia and Herzegovina, indicating that the species does not occur on the eastern sides of Mt. Dinara and Mt. Kamešnica which form the natural border between Croatia and Bosnia and Herzegovina. A similar distribution observed in *Drusus croaticus* (Insecta, Trichoptera), which is recorded only on the western slopes of Mt. Lička Plješivica (Croatia) but not on the eastern slopes of the same mountain (KUČINIĆ *et al.*, 2014). In contrast eight endemic species of the *Drusus bosnicus* Group are distributed in Bosnia and Herze-

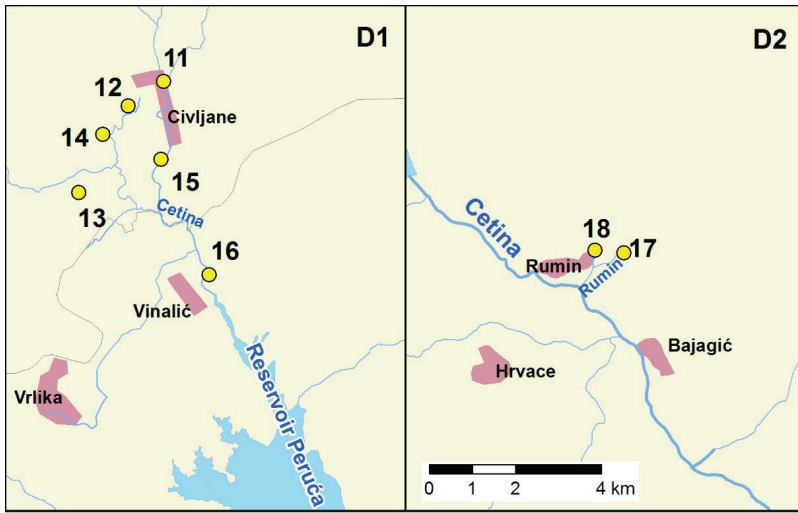


Fig. 5. Distribution of *E. ivokae* in the Cetina River and the Rumin River (details D of the Fig. 6)

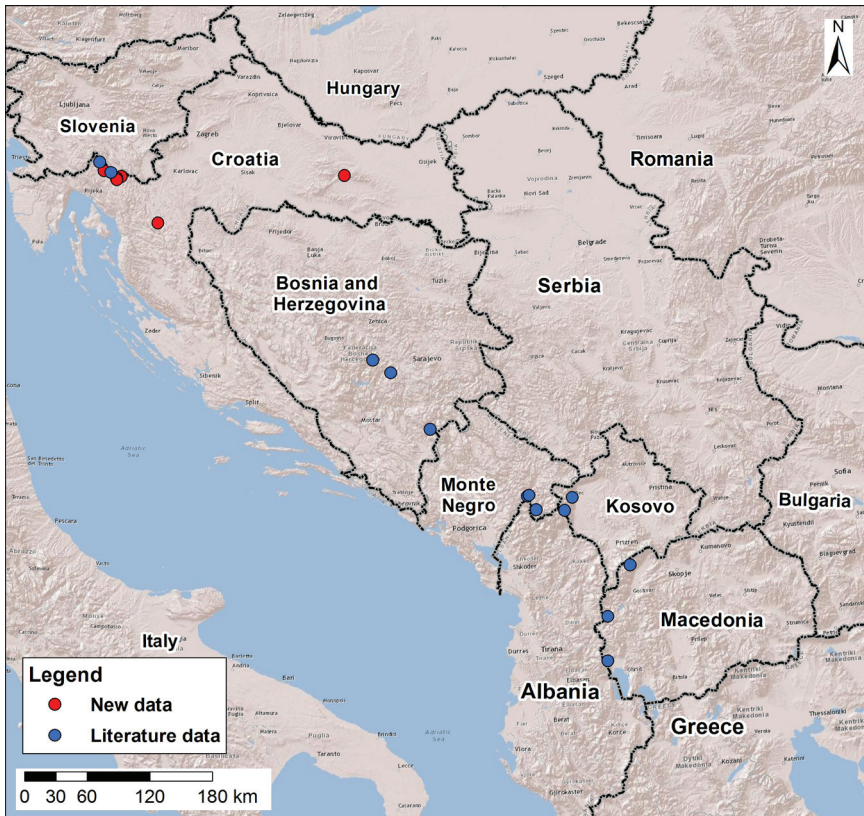


Fig. 6. Distribution of *E. keroveci* in the Western Balkan (according to literature data and new records).

Tab. 2. Physico-chemical parameters of localities with records of *E. keroveci* and *E. irokae*

Sampling station	Dretulja River – Plaški upper reach	Čabranka River – mouth, before entering in Kupa	Kupa – Brod na Kupi	Kupa River – after confluence Čedanaj	Kupica River – mouth before entering in the Kupa	Cetina – Vaukovića spring	Cetina Vimalić	Nele Spring tributary of the Cetina River	Rumin – Veliki Rumin Spring	Veličanka – upper part	Čabranka – spring
species	E. keroveci	E. keroveci	E. keroveci	E. keroveci	E. keroveci	E. ivkae	E. ivkae	E. ivkae	E. ivkae	E. keroveci	E. keroveci
	min. – max.	min. – max.	min. – max.	min. – max.	min. – max.	min. – max.	min. – max.	min. – max.	min. – max.	min. – max.	min. – max.
Water temperature (°C)	7,0 – 11,5	6,0 – 13,4	2,0 – 11,0	2,1 – 18,0	8,2 – 10,3	7,9 – 12,9	7,5–10,8	7,3 – 12,2	7,5 – 13,4	10,0 – 20,0	7,1 – 10,5
Oxygen (mg O ₂ /l)	7,90 – 11,10	10,00 – 12,40	11,60 – 13,50	10,5 – 13,30	11,10 – 12,00	9,60 – 10,20	10,3 – 11,3	10,7 – 13,39	9,50 – 11,60	8,80 – 11,20	10,70 – 12,60
Oxygen saturation, (%)	68,2 – 95,7	95,1 – 101,6	91,8 – 107,8	96,4 – 113,2	97,5 – 104,3	84,5 – 91,0	86,7 – 98,0	98 – 125,9	88,3 – 102,3	99,3 – 101,4	91,2 – 110,3
Conductivity, (µS/cm)	317 – 495	232 – 338	239 – 283	266 – 304	279 – 294	264 – 377	173 – 381	289 – 368	224 – 378	269 – 481	-
pH	7,30 – 8,10	8,20 – 8,60	8,00 – 8,30	8,10 – 8,50	8,20 – 8,40	7,50 – 8,10	7,60 – 8,10	7,85 – 8,13	7,54 – 7,97	8,00 – 8,40	8,00 – 8,2
Alcalinity, (mgCaCO ₃ /l)	170 – 271	156 – 230	121 – 166	128 – 171	173 – 190	127 – 185	146 – 201	160 – 182,5	155 – 170	77,7 – 202,5	347 – 596
COD, (mg O ₂ /l)	0,3 – 1,5	0,6 – 1,6	0,8 – 1,0	0,8 – 4,0	0,7 – 1,4	0,5 – 0,6	0,6 – 0,8	0,5 – 0,6	0,5 – 0,6	1,3 – 2,4	0,4 – 1,5
BOD ₅ , (mg/l)	0,5 – 1,4	1,0 – 1,5	0,6 – 0,8	0,6 – 2,6	0,6 – 1,9	<1,5	<1,5	<1,5	<1,5	0,6 – 1,5	0,4 – 1,5
Ammonia, (mgN/l)	0,03 – 0,11	0,005 – 0,03	0,01 – 0,03	0,01 – 0,06	0,005 – 0,01	<0,01	0,01 – 0,011	0,01 – 0,02	0,01 – 0,03	0,01 – 0,05	0,005 – 0,025
Nitrites, (mgN/l)	0,3 – 1,3	0,39 – 0,73	0,47 – 0,88	0,43 – 1,0	0,48 – 0,98	0,32 – 0,46	0,24 – 0,38	0,33 – 0,43	0,41 – 0,49	0,68 – 1,5	0,45 – 0,66
Total nitrogen, (mgN/l)	0,62 – 1,5	0,48 – 0,87	0,53 – 0,92	0,52 – 1,4	0,51 – 1,1	0,33 – 0,46	0,29 – 0,38	0,31 – 0,44	0,40 – 0,50	1,1 – 1,9	0,53 – 0,76
Orthophosphates, (mgP/l)	0,01 – 0,02	0,005 – 0,01	0,005 – 0,006	0,005 – 0,01	0,005 – 0,01	<0,006	<0,006	0,005 – 0,006	0,005 – 0,006	0,02 – 0,04	0,005 – 0,011
Total phosphorus, (mgP/l)	0,01 – 0,63	0,01 – 0,07	0,02 – 0,03	0,02 – 0,03	0,02 – 0,04	0,01 – 0,02	0,01 – 0,02	0,01 – 0,02	0,01 – 0,02	0,04 – 0,06	0,01 – 0,05

govina Hercegovina (MARINKOVIĆ-GOSPODNETIĆ, 1979; KUČINIĆ *et al.*, 2010; VITECEK *et al.*, 2015). In Croatia *Drusus bosnicus* Group was present only with species *Drusus vespertionis* from spring of the River Una (KUČINIĆ *et al.*, 2014) situated in the eastern part of Lička Plješevica Mt. In the western part of Lička Plješevica Mt. and Kamešnica Mt. *Drusus bosnicus* Group is not distributed.

Ecology

The habitat characteristics of the localities where *E. keroveci* was recorded indicate that the species prefers rhithral sections of streams with substrates mainly composed of mesolithal and macrolithal that is substantially covered with algae and moss. Like investigation of PREVIŠIĆ *et al.*, 2014 we also found similar habitat characteristics.

The habitat characteristics of the localities where *E. ivkae* was recorded indicate that the species has a preference mostly for crenal sections of stream, but may also colonize rhithral sections (PREVIŠIĆ *et al.*, 2014), which is supported by our findings of the species in the Rumin River. The substrate in rivers inhabited by *E. ivkae* was mainly composed of smaller fractions (microlithal and mesolithal) with some larger stones and submerged vegetation at all three locations in the Cetina River and the two locations in the Rumin River.

Analysis of physico-chemical parameters (Tab. 2) indicate high or good water quality. Therefore, both species are probably sensitive to organic pollution. *E. ivkae* is restricted to the spring area, where concentration of organic matter and nutrients are lower than in the middle and lower part of the stream. *E. keroveci* occurs at locations with a wider range of water temperature, as well as a slight increase in organic matter and concentration of nutrients. Population density of population of larval *E. keroveci* was much higher at the river mouths than in the upper parts of streams.

Our study and literature data (PREVIŠIĆ *et al.*, 2014) of collected adults indicate that both species, *E. keroveci* and *E. ivkae* have emergence in the spring and summer months (Tab. 1) and suggest that both species have only one generation and a typical one-year life cycle like some other Drusine species from Dinaric karst area (e.g. KUČINIĆ *et al.*, 2010).

Conservation issues

In the Balkan Peninsula, including some areas in Croatia, considerable numbers of hydropower plants have been planned, many of them focused on mountain springs and spring areas due to their natural hydrological potential. The construction of such hydroelectric facilities can cause changes in morphological and hydrological characteristics at the construction site; consequently, the changed environmental conditions may lead to the endangering or even the loss of certain species. The protection of these habitats is possible, among other things, through protection of endemic and rare species in this area. Due to their limited distribution ranges, both *Ecclisopteryx* species are likely to be endangered if any water abstraction or water pollution occurs.

E. keroveci is not a highly vulnerable species although it requires a certain level of protection. On the other hand, *E. ivkae*, as microendemic species occurring only at a few localities within the Cetina River catchment area, requires absolute protection. Its protection mostly depends on good water quality as well as sustainable, moderate and reasonable water abstraction in order to supply the local area. Successful examples of such

spring protection and water use management of springs that also serve as water supply have been implemented at Brljan spring near Smiljan in Lika (Croatia), where one of the most isolated population of *Drusus croaticus* occurs (KUČINIĆ *et al.*, 2008; PREVIŠIĆ *et al.*, 2009). Another good example is the spring of Paljinska Miljacka (Bosnia and Herzegovina), inhabited by the endemic *Drusus bosnicus* (KUČINIĆ *et al.*, 2015). It is important to establish the eco-agriculture without the use of pesticides and herbicides, because the species *E. ivkae* was recorded in the agricultural field.

We consider that all springs and spring areas should be protected in order to preserve habitats, species and valuable water resources. If some water abstraction in these areas is required, it should be carried out in a sustainable way so that the fauna occurring there is not affected.

For the species *E. ivkae* we propose the IUCN category 'critically endangered' and for the species *E. keroveci* the category 'vulnerable' is suggested (DUPLIĆ *et al.*, 2015; ŠAŠIĆ *et al.*, 2015).

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SAŽETAK

Rod *Ecclisopteryx* (Insecta: Trichoptera: Limnephilidae) u Hrvatskoj: rasprostranjenost i aspekti zaštite

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U posljednja tri desetljeća provode se detaljnija istraživanja faune tulara u Hrvatskoj (Cetina, Drava, Dobra, Krka, Kupa, Kupica i druge rijeke) prema kojima je, uz postojeće literaturne podatke, do sada zabilježeno oko 200 vrsta tulara. U radu su prikazani novi nalazi za vrstu *Ecclisopteryx ivkae* na slivnom području rijeke Cetine i nalazi vrste *Ecclisopteryx keroveci* na slivnom području Kupe i rijeci Veličanki tijekom istraživanja koja su provedena u razdoblju 2014.-2015. godine (NIP projekt) te na osnovu nacionalnog monitoringa kakvoće površinskih voda u sklopu kojeg su prikupljene ličinke ovih vrsta. U radu su predložene i mjere zaštite za obje vrste te status njihove ugroženosti prema IUCN kriterijima.