Entomol. Croat. 2011, Vol. 15. Num. 1-4: 145-161
Proceedings of the XXII Symposium Internationale Entomofaunisticum Europae Centralis

EMERGENCE OF CADDISFLIES (TRICHOPTERA, INSECTA) AT TUFA BARRIERS IN PLITVICE LAKES NATIONAL PARK

Petra ŠEMNIČKI[1], Ana PREVIŠIĆ[2], Marija IVKOVIĆ[2], Kristina ČMRLEC[3] & Zlatko MIHALJEVIĆ[2]

[1]Radoboj 359a, 49232 Radoboj, Croatia.
[2]Department of Zoology, Division of Biology, Faculty of Science, University of Zagreb, Rooseveltov trg 6, 10000 Zagreb, Croatia
[3]Lavoslava Ružičke 19, 43500 Daruvar, Croatia.

ana.previsic@biol.pmf.hr

Accepted: December 19th 2011

Caddisflies were collected in the Plitvice Lakes NP during 2008 using emergence traps at 3 locations at tufa barriers. A total of 2217 specimens, belonging to 44 species, 27 genera and 12 families were recorded during this study. Six species, *Hydroptila cognata*, *Hydroptila occulta*, *Ecnomus tenellus*, *Potamophylax luctuosus*, *Beraeodes minutus* and *Ceraclea annulicornis* are new to the caddisfly fauna of the Plitvice Lakes NP. The highest number of species and individuals were collected at Labudovac barrier and diversity was highest at Labudovac and Novakovića Brod barriers. Emergence peaks for the majority of species at tufa barriers were recorded in the summer. The longest emergence period of seven months was recorded for *Rhyacophila dorsalis plitvicensis* and *Wormaldia subnigra*. Emergence patterns of the most abundant species are in accordance with results of previous studies in the Plitvice Lakes NP. However, discrepancies in emergence patterns compared to their typical emergence patterns could be linked with the specific composition of caddisfly communities at tufa barriers.

Plitvice Lakes NP, caddisflies, emergence, tufa barriers, diversity

P. ŠEMNIČKI, A. PREVIŠIĆ, M. IVKOVIĆ, K. ČMRLEC i Z. MIHALJEVIĆ: Emergencija tulara (Trichoptera, Insecta) na sedrenim barijerama u Nacionalnom Parku Plitvička jezera. Entomol. Croat. Vol. 15. Num. 1-4: 145-161.

Tulari su prikupljani tijekom 2008. godine pomoću emergencijskih klopki, na 3 lokacije na sedrenim barijerama u NP Plitvička jezera. Ukupno je prikupljeno 2217 jedinki te su zabilježene 44 vrste iz 27 rodova i 12 porodica. Šest vrsta, *Hydroptila cognata*, *Hydroptila occulta*, *Ecnomus tenellus*, *Potamophylax luctuosus*, *Beraeodes minutus* i *Ceraclea annulicornis* nove su u fauni NP Plitvičkih jezera. Najveći broj vrsta i jedinki prikupljen je na postaji na barijeri Labudovac, a najveća raznolikost zabilježena je na postajama na barijerama Labudovac i Novakovića Brod. Najveća emergencija na sedrenim barijerama zabilježena je u ljetnom razdoblju. Najduži period emergencije u trajanju od sedam mjeseci zabilježen je za svojte *Rhyacophila dorsalis plitvicensis* i *Wormaldia subnigra.* Emergencijske značajke većine vrsta u skladu su s prethodnim rezultatima istraživanja na području NP Plitvička jezera. Međutim, opažene su određene razlike u odnosu na njihove tipične emergencijske značajke, što bi moglo biti povezano sa specifičnim sastavom zajednica tulara sedrenih barijera.

NP Plitvička jezera, tulari, emergencija, sedrene barijere, raznolikost

Introduction

Caddisflies are one of the most abundant and diverse groups of aquatic insects. They occur in almost every type of freshwater habitat and their distribution covers all continents except Antarctica (Morse, 2003). Larvae build cases from a wide range of mineral and plant materials, the type of material and the shape of the case often identifable in the field for the genus or even for the species (Morse, 2003). Because of the specific habitat requirements and sensitivity to pollution, caddisfly communities are often used for detection and monitoring of freshwater habitats (Graf et al., 2002; Morse, 2003).

Caddisflies in temperate zones mainly complete their life cycle in a single year, but semivoltine cycles also occur in mountainous regions and polyvoltinism in lowlands (Waringer & Graf, 2011). Adult emergence occurs between early spring and winter (Corbet, 1964). As in many other aquatic insect groups, many caddisfly species emerge synchronously *en masse*, which increases the reproductive success (Malicky, 1973). On the other hand, some species have asynchronous emergence patterns and are on the wing most of the season (Malicky, 1973; Graf et al., 2008). The start and patterns of the emergence period are influenced by many environmental factors such as temperature, humidity, moon phase, water flow, light intensity, etc. (Corbet, 1964; Ivković et al 2012). However, inter alia, key factors for the emergence of aquatic insects are water temperature and photoperiod (Corbet, 1964, Ivković et al., 2012).

Plitvice Lakes National Park is located in the mountainous region of Croatia, in the Lika region. It is a barrage-lake system formed by sixteen lakes divided by numerous travertine barriers. Plitvice Lakes National Park was chosen for this study due to high diversity of different freshwater habitat types typical of the karst system, such as springs, streams, lakes and particularly tufa barriers.

The objectives of the present study were (1) to document the species inventory, (2) to investigate caddisfly community composition and (3) to define emergence patterns of species inhabiting tufa barriers with special emphasis on emergence patterns of dominant species.

Materials and Methods

Study area

Caddisflies were collected at three sampling sites in Plitvice Lakes NP, located on three tufa barriers: Labudovac barrier (BL), Kozjak-Milanovac barrier (BKM) and Novakovića Brod barrier (BNB) (Fig. 1).

Figure 1. Map of the study area showing the location of sampling sites in Plitvice Lakes National Park, Croatia (modified from Previšić *et al.* 2007). Abbreviations of the sampling sites: BL – barrier Labudovac, BKM – barrier Kozjak Milanovac, BNB – barrier Novakovića Brod. Symbols indicate location sites at tufa barriers ◆.

Collecting was conducted monthly during 2008 (Jan – Dec 2008) with pyramid-type emergence traps as described in Previšić et al. (2007) and Ivković et al. (2012). At tufa barriers, six traps were placed at each sampling site covering a total surface of 1.215 m^2 (each trap covered 0.20 m^2).

Collected material was preserved in 80 % ethanol. Identification was based on the Atlas of European Trichoptera (Malicky, 2004). Females belonging to the genera *Hydropsyche, Wormaldia* and *Hydroptila* could not be identified to the species level with certainty and therefore are shown as *Hydropsyche* sp., *Wormaldia* sp. and *Hydroptila occulta* group.

Only a summary of results focusing on particular sites (i.e. sampled habitats) is presented in this study and therefore the numbers of specimens collected at each site were pooled. In order to analyse the faunistic diversity of caddisflies, the number of individuals, number of species, the Shannon-Wiener diversity index (Shannon, 1948), the Simpson diversity index (Simpson, 1949) and equitability (Pielou, 1969) were calculated for each site. Emergence patterns are shown and analysed in detail for the dominant species, i.e. species accounting for > 10 % of the total catch at a particular site.

Results and Discussion

Composition and diversity of caddisfly communities at tufa barriers

A total of 2217 specimens, belonging to 44 species, 27 genera and 12 families were recorded during the current study (Table 1). Limnephilidae was the most diverse family, represented by 9 species, followed by Leptoceridae represented by 7 species.

The documentation of six species (*Hydroptila cognata* Mosely, 1930, *Hydroptila occulta* Eaton, 1873, *Ecnomus tenellus* Rambur, 1842, *Potamophylax luctuosus* (Piller & Mitterpacher 1783), *Beraeodes minutus* (Linnaeus 1761) and *Ceraclea annulicornis* (Stephens, 1836)) represents the first records for the caddisfly fauna of Plitvice Lakes National Park (Table 1).

The highest number of individuals at barriers were collected at Labudovac barrier, followed by Kozjak-Milanovac barrier, whereas the lowest number of individuals were collected at Novakovića Brod barrier (Fig. 2 & Table 2). The highest and the lowest numbers of species at barriers were collected at Labudovac barrier and Kozjak-Milanovac barrier, respectively (Table 2). Shannon-Wieners's and Simpson's diversity indices were highest at Labudovac and Novakovića Brod

Table 1. Inventory of caddisfly species, showing the number of males and females collected per m^2 and absolute number of individuals collected (in brackets) with emergence traps during 2008 at 3 tufa barriers in Plitvice Lakes NP. For the abbreviations of the sampling sites see legend of Figure 1.* females, ** new record for caddisfly fauna of Plitvice Lakes NP.

Species	BL		BKM		BNB		Total number
	m	f	m	f	m	f	
RHYACOPHILIDAE							
Rhyacophila aurata Brauer, 1857	2.5 (3)		0.8 (1)	0.8 (1)		0.8 (1)	5.8 (7)
Rhyacophila dorsalis plitvicensis Kučinić &Malicky, 2002	21.4 (26)	19.8 (24)	5.8 (7)	7.4 (9)	12.3 (15)	24.7 (30)	91.4 (111)
R. schmidinarica Urbanič, Krušnik & Malicky, 2000					0.8 (1)		0.8 (1)
Rhyacophila tristis Pictet, 1834	22.2 (27)	16.5 (20)	2.5 (3)	1.6 (2)	1.6 (5)	0.8 (1)	45.3 (55)
HYDROPTILIDAE							
***Hydroptila cognata* Mosely, 1930			0.8 (1)				0.8 (1)
Hydroptila occulta (Eaton, 1873)	0.8 (1)						0.8 (1)
Hydroptila occulta Group		0.8 (1)		1.6 (2)		4.9 (6)	7.4 (9)
PHILOPOTAMIDAE							
Wormaldia occipitalis (Pictet, 1834)					6.6 (8)	2.5 (3)	9.1 (11)
Wormaldia subnigra McLachlan, 1865	14.8 (18)		66.7 (81)		63.4 (77)		144.9 (176)

Table 1. Continued

**Wormaldia* sp.		25.5 (31)		288.9 (351)		100.4 (122)	414.8 (504)
Philopotamus variegatus (Scopoli, 1763)	3.3 (4)	1.6 (2)		0.8 (1)	20.6 (25)	13.2 (16)	39.5 (48)
ECNOMIDAE							
***Ecnomus tenellus* Rambur, 1842					0.8 (1)	1.6 (2)	2.5 (3)
POLYCENTROPODIDAE							
Cyrnus trimaculatus (Curtis, 1834)					0.8 (1)		0.8 (1)
Neureclipsis bimaculata (Linnaeus, 1758)		4.9 (6)	0.8 (1)				5.8 (7)
Polycentropus excisus Klapalek, 1894					0.8 (1)		0.8 (1)
Polycentropus flavomaculatus (Pictet, 1834)	6.6 (8)	8.2 (10)			0.8 (1)		15.6 (19)
Polycentropus schmidi Novak & Botosaneanu, 1965	2.5 (3)	1.6 (2)		4.1 (5)		1.6 (2)	9.9 (12)
PSYCHOMYIDAE							
Lype phaeopa (Stephens, 1836)		4.9 (6)		3.3 (4)			8.2 (10)
Lype reducta (Hagen, 1868)	6.6 (8)				3.3 (4)		9.9 (12)
Tinodes dives (Pictet, 1834)		3.3 (4)			0.8 (1)	1.6 (2)	5.8 (7)
Tinodes unicolor (Pictet, 1834)	2.5 (3)	3.3 (4)					5.8 (7)
Tinodes waeneri (Linnaeus, 1758)					0.8 (1)		0.8 (1)
HYDROPSYCHIDAE							

Table 1. Continued

Hydropsyche instabilis (Curtis, 1834)	97.1 (118)		0.8 (1)				97.9 (119)
Hydropsyche saxonica McLachlan, 1884	155.6 (189)		22.2 (27)		11.5 (14)		189.3 (230)
**Hydropsyche* sp.		345.7 (420)		51.9 (63)		32.1 (39)	429.6 (522)
LEPIDOSTOMATIDAE							
Lepidostoma hirtum Fabricius, 1775)	4.1 (5)	7.4 (9)					11.5 (14)
LIMNEPHILIDAE							
Glyphotaelius pellucidus (Retzius, 1783)			0.8 (1)	4.1 (5)			4.9 (6)
Limnephilus lunatus Curtis, 1834	27.2 (33)	28.8 (35)	10.7 (13)	11.5 (14)			78.2 (95)
Limnephilus rhombicus (Linnaeus, 1758)	0.8 (1)	0.8 (1)					1.6 (2)
Chaetopteryx fusca Brauer, 1857		0.8 (1)					0.8 (1)
Halesus digitatus (Schrank, 1781)	2.5 (3)	0.8 (1)					3.3 (4)
Halesus tesselatus (Rambur, 1842)		0.8 (1)					0.8 (1)
Potamophylax latipennis (Curtis, 1834)					1.6 (2)		1.6 (2)
***Potamophylax luctuosus* (Piller & Mitterpacher 1783)						0.8 (1)	0.8 (1)
Potamophylax pallidus (Klapalek, 1899)	10.7 (13)	4.1 (5)					14.8 (18)

Table 1. Continued

SERICOSTOMATIDAE							
Sericostoma flavicorne Schneider, 1845	0.8 (1)						0.8 (1)
Notidobia ciliaris (Linnaeus, 1761)	4.1 (5)	3.3 (4)			0.8 (1)		8.2 (10)
BERAEIDAE							
***Beraeodes minutus* (Linnaeus 1761)				0.8 (1)			0.8 (1)
Beraeamyia schmidi Botosaneanu, 1960	28.0 (34)	26.3 (32)	2.5 (3)	5.8 (7)	4.1 (5)	0.8 (1)	67.5 (82)
Ernodes vicinus (McLachlan, 1879)		0.8 (1)					0.8 (1)
LEPTOCERIDAE							
Adicella syriaca Ulmer, 1907		0.8 (1)	3.3 (4)	10.7 (13)	0.8 (1)	0.8 (1)	16.5 (20)
Mystacides azurea (Linnaeus, 1761)	4.9 (6)	2.5 (3)	0.8 (1)	0.8 (1)			9.1 (11)
Athripsodes bilineatus (Linnaeus, 1758)	0.8 (1)	0.8 (1)	9.1 (11)	15.6 (19)	5.8 (7)	7.4 (9)	39.5 (48)
Athripsodes cinereus (Curtis 1834)		0.8 (1)					0.8 (1)
***Ceraclea annulicornis* (Stephens, 1836)				0.8 (1)			0.8 (1)
Ceraclea dissimilis (Stephens, 1836)	0.8 (1)			1.6 (2)	0.8 (1)		3.3 (4)
Oecetis testacea (Curtis, 1834)	5.8 (7)	5.8 (7)	1.6 (2)		0.8 (1)	0.8 (1)	14.8 (18)
Total number	426.3 (518)	521 (633)	129.2 (157)	412.3 (501)	139.9 (170)	195.9 (238)	1824.6 (2217)

barriers, respectively. Equitability was also highest at Novakovića Brod barrier (Table 2). Lowest diversity and equitability were recorded at the Kozjak-Milanovac barrier, however, generally no marked differences between sites were observed (Table 2). A wide range of food resources and high concentration of organic matter compared to downstream barriers (Horvatinčić et al., 2006; Špoljar et al. 2007), and the variety of microhabitats are probably the main reasons for highest population density and species richness at Labudovac barrier (Waringer, 1996; Wiberg-Larsen et al., 2000; Habdija et al., 2004; Miliša et al., 2006; Šemnički et al., submitted).

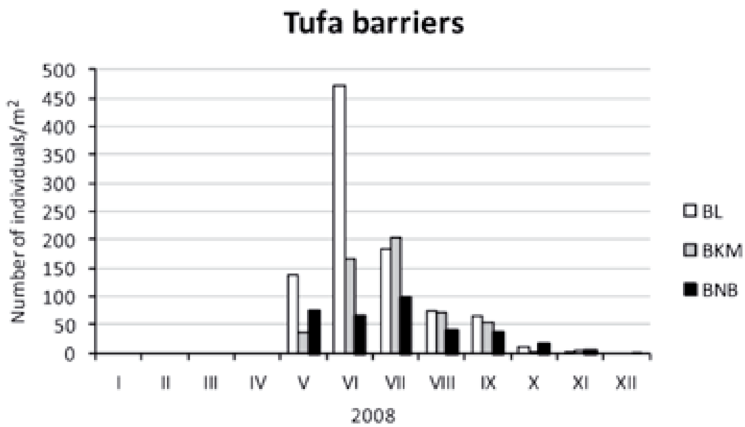


Figure 2. Monthly number of individuals per m^2 recorded at 3 tufa barriers in Plitvice Lakes NP in 2008. For the abbreviations of the sampling sites see legend of Figure 1.

Table 2. Species richness - S, total number of individuals collected (shown as number of individuals/m^2 and absolute values) – N, and diversity of caddisflies caught by emergence traps at 3 tufa barriers in Plitvice Lakes NP. H' - Shannon-Wiener diversity index, D - Simpson's diversity index and E – equitability; for the abbreviations of the sampling sites see legend of Figure 1.

Site	S	N	H'	D	E
BL	32	947.3 / 1151	2.273	0.816	0.644
BKM	22	541.5 / 658	1.764	0.683	0.555
BNB	26	335.8 / 408	2.240	0.839	0.679

The most abundant taxa (> 10 % of total catch per site) were *Hydropsyche instabilis* (Curtis, 1834), *Hydropsyche saxonica* McLachlan, 1884, *Hydropsyche* females, *Wormaldia subnigra* McLachlan, 1865, *Wormaldia* females, *Rhyacophila dorsalis plitvicensis* Malicky & Kučinić, 2002 and *Philopotamus variegatus* (Scopoli, 1763).

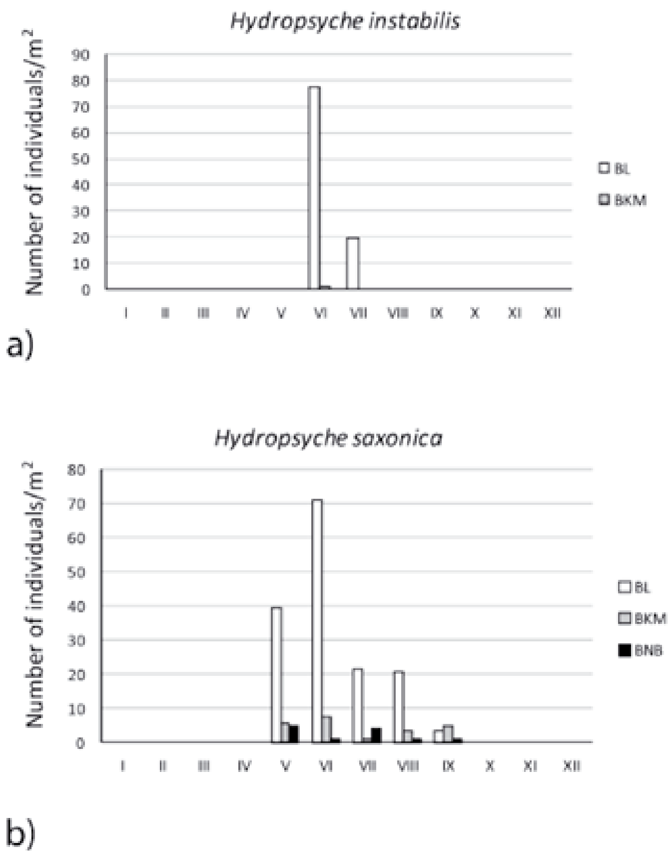
In the community at Labudovac barrier, *Hydropsyche* was the most abundant taxon, accounting for 63.2 % of the total catch at this site, *Hydropsyche* females accounting for 36.9 % of the catch. At both Kozjak-Milanovac and Novakovića Brod barriers, the community was dominated by *Wormaldia* species, comprising 65.6 % and 51.5 % of the total catch, respectively (Table 1).

According to their typical longitudinal distribution, *H. instabilis, H. saxonica* and *W. subnigra* are typical stream inhabitants, only partially overlapping in their distribution (Graf et al., 2002; 2008). *H. saxonica* is common in shaded forest streams (Waringer & Graf, 1997) and *H. instabilis* in mountainous streams at higher altitudes (Waringer & Graf, 2011). High abundance of these species at tufa barriers is most probably associated with a specific combination of environmental factors in these habitats, rather than a typical longitudinal distribution, although passive filter-feeders dominate the community (Graf et al., 2008). Since the barriers are located between lakes they represent natural lake outlet habitats. However, caddisfly community composition at tufa barriers is not typical for lake outlet habitats (e.g. Giller & Malmquist, 1998; for further discussion see Šemnički et al., submitted).

Emergence patterns

The complete period of emergence for all collected species is presented in Table 3. Generally, the emergence of caddisflies at barriers was recorded from May to December and maximum emergence occurred in summer (Table 3, Fig. 2). Highest number of species was recorded in June at all three barriers (22 at BL, 16 at BKM and 14 at BNB). However, emergence peaks regarding number of emerged individuals differed among the barriers, with highest numbers collected in June and in July, at the upstream Labudovac barrier and both downstream barriers, respectively (Fig. 2).

Variability in the emergence period can be observed due to differences in the life cycle of each species. The longest emergence period of seven months was recorded for *R. dorsalis plitvicensis* and *W. subnigra* (Table 3). The emergence period for *R. dorsalis plitvicensis* reported by Previšić et al. (2007) is consistent with our observed emergence period of seven months from late spring to late autumn (Fig. 3c). Predatory caddisfly species, like *Rhyacophila* species, generally have longer emergence periods than species belonging to other feeding types, since their food is available throughout the year (Otto, 1981).



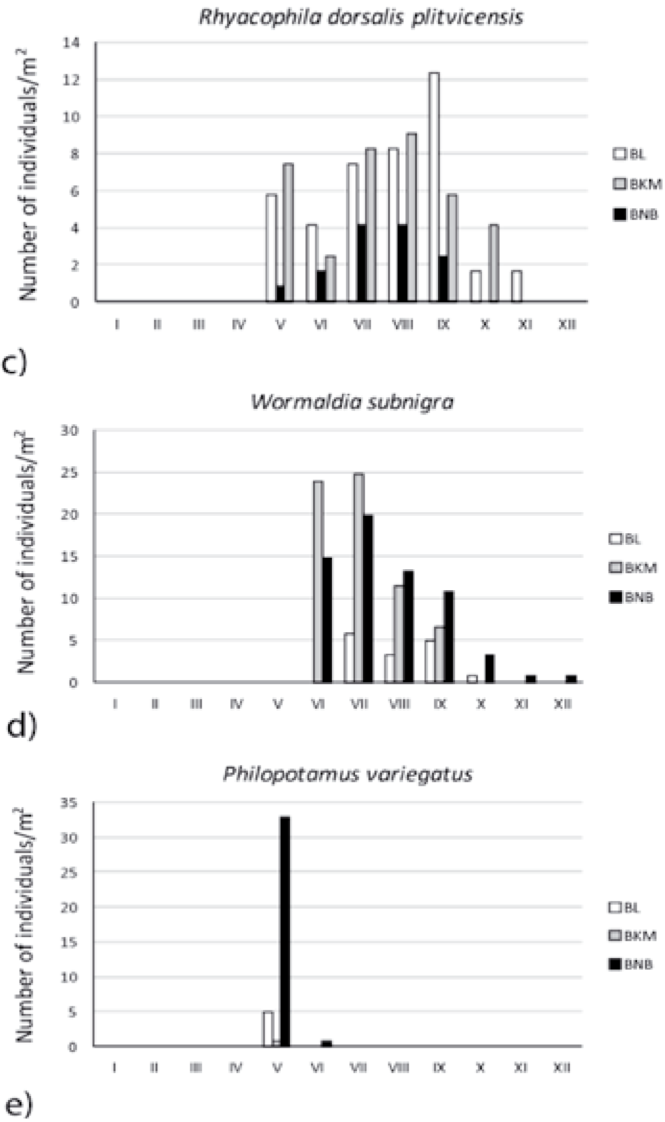


Figure 3. Emergence patterns of the five most abundant species at tufa barriers in 2008 (shown as number of individuals/m^2 per month). For the abbreviations of the sampling sites see legend of Figure 1.

In addition to *R. dorsalis plitvicensis*, *Polycentropus schmidi* Novak & Botosaneanu, 1965 also represents a species with generally insufficiently investigated ecology, including emergence patterns (Graf et al., 2008; Waringer & Graf, 2011). Although it was present in low numbers within this study, the emergence period from June to August was recorded for this species at tufa barriers (Table 3).

Table 3. The period of emergence shown for all species collected during 2008 by emergence traps at tufa barriers in Plitvice Lakes NP.

Species	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Rhyacophila aurata					♦	♦	♦	
Rhyacophila dorsalis plitvicensis	♦	♦	♦	♦	♦	♦	♦	
Rhyacophila schmidinarica	♦							
Rhyacophila tristis	♦	♦	♦					
Hydroptila cognata			♦					
Hydroptila occulta		♦						
Hydroptila occulta group		♦	♦					
Philopotamus variegatus	♦	♦						
Wormaldia occipitalis	♦							
Wormaldia subnigra		♦	♦	♦	♦	♦	♦	♦
Wormaldia sp. ♀♀		♦	♦	♦	♦	♦	♦	
Cyrnus trimaculatus		♦	♦	♦	♦			
Neureclipsis bimaculata	♦	♦	♦					
Polycentropus excisus				♦				
Polycentropus flavomaculatus		♦	♦	♦	♦	♦		
Polycentropus schmidi		♦	♦	♦				
Lype phaeopa	♦	♦	♦	♦				
Lype reducta	♦	♦						
Tinodes dives	♦	♦	♦	♦				
Tinodes unicolor			♦	♦				
Tinodes waeneri		♦						
Ecnomus tenellus			♦	♦				
Hydropsyche instabilis		♦	♦					
Hydropsyche saxonica	♦	♦	♦	♦	♦			
Hydropsyche sp. ♀♀	♦	♦	♦	♦	♦	♦		
Lepidostoma hirtum		♦	♦	♦	♦			
Chaetopteryx fusca	♦	♦						

Table 3. - continued

Glyphotaelius pellucidus	♦	♦						
Halesus digitatus					♦	♦		
Halesus tesselatus					♦			
Limnephilus lunatus	♦	♦	♦	♦	♦			
Limnephilus rhombicus		♦						
Potamophylax latipennis					♦			
Potamophylax luctuosus					♦			
Potamophylax pallidus					♦			
Notidobia ciliaris	♦		♦					
Sericostoma flavicorne		♦						
Beraeamyia schmidi	♦	♦	♦					
Beraeodes minutus	♦							
Ernodes vicinus		♦						
Adicella syriaca		♦	♦	♦	♦			
Athripsodes bilineatus		♦	♦	♦				
Athripsodes cinereus		♦						
Ceraclea annulicornis		♦						
Ceraclea dissimilis		♦	♦		♦			
Mystacides azurea	♦	♦	♦	♦	♦			
Oecetis testacea		♦	♦		♦			
Number of species	19	33	26	18	19	8	4	1

W. subnigra had an extended emergence period from June to December at Novakovića Brod barrier, while at Labudovac and Kozjak-Milanovac barriers this species emerged from June to September, which is consistent with the emergence period reported by Previšić et al. (2007) (Fig. 3d). In contrast, *Rhyacophila schmidinarica* Urbanič, Krušnik & Malicky, 2000, *Hydroptila cognata* Mosely, 1930, *Hydroptila occulta* (Eaton, 1873), *Wormaldia occipitalis* (Pictet, 1834), *Polycentropus excisus* Klapalek, 1894, *Tinodes waeneri* (Linnaeus, 1758), *Limnephilus rhombicus* (Linnaeus, 1758), *Sericostoma flavicorne* Schneider, 1845, *Beraeodes minutus* (Linnaeus 1761), *Ernodes vicinus* (McLachlan, 1879), *Athripsodes cinereus* (Curtis 1834) and *Ceraclea annulicornis* (Stephens, 1836) had a short emergence period of only one month duration in spring and summer (Table 2). Emergence periods for *W. occipitalis, T. waeneri, L. rhombicus, S. flavicorne, A. cinereus* and *C. annulicornis* reported by Waringer (1989), Previšić et al. (2007) and Graf et al. (2008) were more extended than the emergence periods recorded in our study.

P. variegatus had a short emergence period from May to June, which is consistent with the typical emergence period reported for this species (Waringer, 1996; Graf et al., 2008) (Fig. 3e).

Most species emerged during the summer, while *Halesus digitatus* (Schrank, 1781), *Halesus tesselatus* (Rambur, 1842), *Potamophylax latipennis* (Curtis, 1834), *Potamophylax luctuosus* (Piller & Mitterpacher, 1783) and *Potamophylax pallidus* (Klapálek, 1899) emerged in autumn, which is consistent with their typical life cycle and the period of emergence (Malicky, 1973; Waringer & Graf, 1997) (Table 3). However, some of these species, such as *L. rhombicus, P. latipennis* and *P. pallidus* typically have a long emergence period (Graf et al. 2008).

H. instabilis had a short, summer emergence of 2 month duration (Fig. 3a). *H. saxonica* had an emergence period from May to September (Fig. 3b), which is not in accordance with the typical duration of the emergence period in these species (i.e. long in *H. instabilis* and short in *H. saxonica*; Graf et al. 2008). However, it is in accordance with previous data on emergence period in these species at tufa barriers in the Plitvice Lakes NP (Previšić et al., 2007).

Generally, discrepancies in duration of emergence periods recorded in some species within the current study compared to their typical emergence period could be linked with the specific composition of caddisfly communities at tufa barriers (Šemnički et al. submitted). Some of the species for which we have recorded short emergence periods typically have a long emergence period and are also typical inhabitants of springs and/or streams, not lake outlets (e.g. *W. occipitalis, P. excisus, T. unicolor, H. instabilis, G. pellucidus, P. pallidus*; Graf et al., 2008).

Acknowledgements

The authors would like to thank Professor Dr. Mladen Kerovec for financially supporting this study. We also thank Miljenko Ivković for his help with collecting of caddisflies in the Plitvice Lakes NP. We are grateful to the Plitvice

Lakes National Park authorities, for their support and permission in field sampling. We appreciate the constructive comments of two reviewers, Dr. Wolfram Graf and Professor Dr. Johann Waringer, which improved the manuscript considerably. This research was supported by Croatian Ministry of Science, Education and Sports as a part of the Project no. 119-1193080-3076.

References

CORBET, P. S., 1964. Temporal patterns of emergence in aquatic insects. Canad. Ent. 96: 264-279.

GILLER, P. S. & MALMQVIST, B., 1998. The Biology of Streams and Rivers. Oxford University Press Oxford, 296 pp.

GRAF, W., GRASSER, U. & WARINGER, J., 2002. Trichoptera. Part III. Moog, O. (ed.): Fauna Aquatica Austriaca, Version 2002, Wasserwirtschaftskataster, Bundesministerium für Land- und Forstwirtschaft Wien, 1-41 pp..

GRAF, W., MURPHY, J., DAHL, J., ZAMORA-MUŇOZ, C. Q. & LÓPEZ-RODRÍGEZ, M. J., 2008. Distribution and ecological preferences of european freshwater organisms. Volumen 1. Trichoptera. Pensoft Sofia-Moscow, 388 pp..

HABDIJA, I., PRIMC-HABDIJA, B., MATONIČKIN, R., KUČINIĆ, M., RADANOVIĆ, I., MILIŠA, M. & MIHALJEVIĆ, Z., 2004. Current velocity and food supply as factors affecting the composition of macroinvertebrates in bryophyte habitats in karst running water. Biol. Brat. 59: 577–593.

HORVATINČIĆ, N., BRIANSO, J. L., OBELIĆ, B., BAREŠIĆ J. & KRAJCAR BRONIĆ, I., 2006. Study of pollution of the Plitvice lakes by water and sediment analyses. Water Air Soil Poll. Focus 6: 475-485.

IVKOVIĆ, M., MIČETIĆ STANKOVIĆ, V. & MIHALJEVIĆ, Z., 2012. Emergence patterns and microhabitat preference of aquatic dance flies (Empididae; Clinocerinae and Hemerodromiinae) on a longitudinal gradient of barrage lake system. Limnologica. 42: 43-49.

MALICKY, H., 1973. Trichoptera (Handbuch der Zoologie). Walter de Gruyter Berlin, 114 pp.

MALICKY, H., 2004. Atlas of European Trichoptera. Springer Dordrecht, 359 pp.

MILIŠA, M., HABDIJA, I., PRIMC-HABDIJA, B., RADANOVIĆ, I. & MATONIČKIN KEPČIJA, R., 2006. The role of flow velocity in the vertical distribution of particulate organic matter on moss- covered travertine barriers of the Plitvice Lakes (Croatia). Hydrobiologia 553: 231–243.

MORSE, J. C., 2003. Trichoptera („Caddisflies“). Clemson University. Resh, V. H. & Card R. T. (ed.): Encyclopedia of Insects. Elsevier Science, 1145-1151.

OTTO, C., 1981. Why does duration of flight periods differ in caddisflies? Oikos, 37: 383-386.

PIELOU, E. C., 1969. An Introduction to Mathematical Ecology. John Wiley and Sons New York, 286 pp.

PREVIŠIĆ, A., KEROVEC, M. & KUČINIĆ, M. 2007. Emergence and composition of Trichoptera from karst habitats, Plitvice Lakes region, Croatia. Internat. Rev. Hyrobiol. 92: 61-83.

SHANNON, C. E., 1948. A mathematical theory of communication. AT. & T. Tech. J. 27: 379-423.

SIMPSON, E. H., 1949. Measurement of diversity. Nature 163: 1-688.

ŠEMNIČKI, P., PREVIŠIĆ, A., IVKOVIĆ, M., ČMRLEC, K. & MIHALJEVIĆ, Z. (submitted) Tufa barriers from a caddisfly's point of view: streams or lake outlets? Internat. Rev. Hyrobiol.

ŠPOLJAR, M., PRIMC-HABDIJA, B. & HABDIJA, I., 2007. Transport of seston in the karstic hydrosystem of the Plitvice Lakes (Croatia). Hydrobiol. 579: 199-209.

WARINGER, J. A., 1989. The abundance and temporal distribution of caddisflies (Insecta: Trichoptera) caught by light traps on the Austrian Danube from 1986 to 1987. Freshw. Biol. 21: 387-399.

WARINGER, J. A., 1996. Phenology and abundance of Ephemeroptera, Plecoptera and Trichoptera caught by emergency traps at the Weidlingbach near Vienna, Austria. Internat. Rev. Hydrobiol. 81: 63-77.

WARINGER, J. & GRAF, W., 1997. Atlas der Österreichischen Köcherfliegenlarven. Facultus Universitätsverlag Wien, 286 pp.

WARINGER, J. & GRAF, W., 2011. Atlas der mitteleuropäischen Köcherfliegenlarven – Atlas of Central European Trichoptera Larvae. Erik Mauch Verlag Dinkelscherben, 468 pp.

WIBERG-LARSEN, P., BRODERSEN, K. P., BIRKHOLM, S., GRØN, P. N. & SKRIVER, J., 2000. Species richness and assemblage structure of Trichoptera in Danish streams. Freshw. Biol. 43: 633-647.