

## **LIGHT-TRAPPED CADDISFLIES (INSECTA: TRICHOPTERA) AS INDICATORS OF THE ECOLOGICAL INTEGRITY OF THE LIŠTICA RIVER, BOSNIA AND HERZEGOVINA**

Svjetlana STANIĆ-KOŠTROMAN<sup>1</sup>, Mladen KUČINIĆ<sup>2</sup>, Adriana KOLOBARA<sup>1</sup>, Dragan ŠKOBIĆ<sup>1</sup>, Lejla KNEZOVIĆ<sup>1</sup> & Paula DURBEŠIĆ<sup>2</sup>

<sup>1</sup> Faculty of Science and Education, University of Mostar, Matice hrvatske bb, 88000 Mostar, Bosnia and Herzegovina, svjetlana.stanic@sve-mo.ba

<sup>2</sup> Department of Biology, Faculty of Science, University of Zagreb, Rooseveltov trg 6, 10000 Zagreb, Croatia

Accepted: July, 11<sup>th</sup> 2012

A study of caddisfly biodiversity and its application for use as indicator species to assess the ecological integrity of aquatic environments was conducted in the area of the Lištica River, Bosnia and Herzegovina. A portable UV light-trap was used to collect caddisflies at two sites: the spring of Lištica - Bilo Vrilo and the middle reach of this river in a karstic depression - Mostarsko Blato. From March 2003 to March 2004 a total of 4334 individuals, representing 34 species, were caught. There were significant differences in species composition and abundance between sampling sites. The flight periods are shown for all recorded species and studied in detail for twelve abundant species. The species inventories were used for analysing the longitudinal classification of the sampling sites, composition of functional feeding guilds and the saprobic indices.

### **Caddisflies, Lištica River, Bosnia and Herzegovina, ecological integrity**

S. STANIĆ-KOŠTROMAN, M. KUČINIĆ, A. KOLOBARA, D. ŠKOBIĆ, L. KNEZOVIĆ i P. DURBEŠIĆ: Odrasli tulari (Insecta: Trichoptera) kao pokazatelji ekološkog statusa rijeke Lištice, Bosna i Hercegovina. Entomol. Croat. 2012. Vol. 16. Num. 1-4: 21-35.

Istraživana je bioraznolikost tulara rijeke Lištice te primjena njihovih zajednica u procjeni ekološkog statusa vodenih ekosustava. Odrasle jedinke uzorkovane su na dvjema postajama, tj na izvoru rijeke Bilo vrilo i središnjem dijelu toka Lištice, u krškom polju Mostarskom blatu. Materijal je prikupljan godinu dana (ožujak 2003. – ožujak 2004.) metodom lova pomoću UV lampe. Istraživanjima su zabilježene 34 vrste s 4334 uzorkovanih jedinki. Utvrđene

su značajne razlike u fauni tulara na dvjema istraživanim postajama, koje su se ogledale u sastavu zajednica i brojnosti uzorkovanih jedinki. U radu je prikazan period aktivnosti svih zabilježenih vrsta te je analizirana sezonska dinamika dvanaest vrsta s najvećim brojem uzorkovanih jedinki. Na temelju sastava zajednica odraslih tulara određeni su indeksi saprobnosti, rasprostranjenost hranidbenih skupina te longitudinalna klasifikacija staništa.

### **Tulari, Lištica, Bosna i Hercegovina, ekološki status**

#### **Introduction**

The term “ecological integrity” is frequently used in surface water monitoring programs as a measure of the global condition of aquatic ecosystems (Chatzinikolaou et al., 2008; Oliviera & Cortes, 2006). This approach has been incorporated in the EU 2000/60 Water Framework Directive (WFD), which obliges member states to achieve at least “good quality status” (class II within a five class system) for all surface waters before 2015 (European Union, 2000; Irmer, 2000).

The ecological status of water bodies has to be assessed by comparing the current state of a river with its type-specific reference condition, which should be near pristine and minimally altered by man (European Union, 2000). This approach requires the recording of a variety of parameters in order to detect different types of disturbances (e.g. physicochemical degradation, hydrological fluctuations, physical habitat impairment) (Chatzinikolaou et al., 2008). Disruptions can also be seen by biotic alternations: quantitative and qualitative changes in species assemblage that can lead to either the disappearance of naturally occurring species or the appearance of atypical ones. The most important criteria for the classification of ecological integrity by using biological elements include analyses of species composition and abundance, composition of functional-feeding guilds, shifts in the longitudinal zonation patterns of biocoenotic communities and saprobic indices (Moog, 2002).

Trichoptera represent key species for assessing the ecological status of aquatic habitats (Waringer & Graf, 2006). High species diversity, various ecological and behavioural specializations and very strict environmental requirements, particularly along the longitudinal continuum, make caddisfly larvae excellent study organisms for environmental gradient studies (Bonada, 2004; Holzenthal et al., 2007; Mackay & Wiggins, 1979; Morse, 2003). Since adult caddisflies stay close to their water habitats in most species (Collier & Smith, 1998; Petersen et

al., 2004; Svensson, 1972, 1974) and adult assemblages accurately reflect larval assemblages, a proven collecting technique for using caddisflies as environmental indicators is light-trapping (Chantaramongkol, 1983; Malicky & Chantaramongkol, 1993; Schmera, 2003; Smith et al., 2002; Waringer, 1989, 2003; Waringer & Graf, 2006). This method is also useful in faunistic and ecological investigations and allows various aspects such as changes in insect populations, flight patterns, life history etc to be studied (Collier et al., 1997; Crichton et al., 1978; Tsuruishi, 2003).

The present investigation used light-trapping for studying caddisflies of the Lištica River in Herzegovina. The study provides information on the species composition, phenology and use of caddisfly assemblages for analysing saprobic indices, the composition of functional feeding guilds and stream zonation patterns.

### Material and Methods

The study was conducted in the area of the Lištica River, situated in southwestern Bosnia and Herzegovina. Lištica is a perennial karst river; its springs are located in the vicinity of the town of Široki Brijeg and its sinkholes are located on the eastern part of the karstic field Mostarsko Blato. Due to its geographical location, this area is characterized by a sub-Mediterranean climate, i.e. temperate warm humid climate with hot summers (Cfa), according to the Köppen's climatic classification (Miličević, 2009).

The study was carried out at two sampling sites: the spring of the Lištica, Bilo Vrilo (L1), and the middle reach of this river (L2). Bilo Vrilo is the lowest of the six springs of the Lištica River, located at an altitude of 297 m. It is rheocrene-type karst spring, which is used as a source of drinking water; the associated construction works did not significantly alter the habitat. The second site is located in the central part of the karstic depression Mostarsko Blato, at an altitude of 231 m. This area has been greatly affected by human activity, such as agriculture, water utilization and regulation. All these factors, together with the extraction of gravel and sand from the Lištica riverbed, have negatively affected the river, either directly or indirectly (Miličević, 2009; Zelenika et al., 2005). Physical and chemical parameters of the water at the sampling sites are presented in Table 1.

Adult caddisflies were collected using an ultraviolet light trap from March 2003 to March 2004. The light trap, which was placed within 1 m of the stream edge, was operated for two hours every fifteen days at both sites. The collected

Table 1. Characteristics of the two sampling sites of the Lištica River (L1 –Bilo Vrilo spring, L2 – middle reach of the river).

Site	L1	L2
Elevation (m)	297	231
Latitude	N 43°23'43,3"	N 43°21'11,8"
Longitude	E 17°35'46,2"	E 17°40'32,8"
Substrate composition	stones, gravel	stones, gravel, sand
Water temperature (°C) min/max	8,5/10,2	9,2/13,2
Dissolved O <sub>2</sub> (mg/l) min/max	9,70/14,09	5,14/10,83
Oxygen saturation (%) min/max	89,1/124,3	45,8/103,5
Conductivity (µS/cm) min/max	342/525	356/495
pH min/max	7,09/7,74	6,2/8,17
Dissolved CO <sub>2</sub> (mg/l) min/max	22,0/92,4	17,6/57,2
Alkalinity (mgCaCO <sub>3</sub> /l) min/max	127,6/210,0	153,0/190,0
Total suspended solids – 105°C* (mg/l)	256,0	202,0
Total dissolved solids - 180°C* (mg/l)	142,0	194,0
Total hardness* (mgCaCO <sub>3</sub> /l)	201,5	236,5
Consumption of KMnO <sub>4</sub> * (mg/l)	0,62	1,18
Chemical oxygen demand* (mg/l)	3,1	7,3
Chloride* (mg/l)	5,49	5,95
Phosphate* (mg/l)	0,0	< 0,01
Ammonia* (mg/l)	0,0	0,0
Nitrite* (µg/l)	0,0	<0,05
Nitrate* (mg/l)	0,0	0,34

(Data unpublished except \* Talić *et al.*, 2007)

specimens were preserved in 70 % ethanol in the field, and identified in the laboratory using a SZX 10 stereomicroscope (Olympus, Japan). Identification and the systematic review were based on Malicky (2004, 2005). The nomenclature follows Graf *et al.*, 2008.

Species similarity between samples from both sampling sites was calculated using the Sørensen index (Krebs, 1999) and biocoenotic metrics (saprobic index, longitudinal zonation patterns, functional feeding guilds) based on species-specific indices (Graf *et al.*, 2002, 2008) were calculated using the procedure given by Moog (2002).

## Results and Discussion

From March 2003 to March 2004 a total of 4334 specimens were collected by the light trap at two sites at the Lištica River (Table 2). Among the 34 recorded species, 18 were found in the spring Bilo Vrilo (L1) and 23 species were caught in the middle reach of the Lištica (L2). The composition of the caddisfly fauna between L1 and L2 differed considerably; only 7 species were common to both sites. Thus, the Sørensen similarity index between the two sampling sites was low (34 %).

At the sampling site in the spring of the Lištica River a total of 629 specimens were collected (Table 2). Sixty-one percent of the total catch consisted of three species: *Drusus ramae* Marinković, 1970, *Glossosoma bifidum* McLachlan, 1879 and *Rhyacophila balcanica* Radovanović, 1953. The most abundant species was *D. ramae* with 149 specimens collected. This species belongs to the group of 13 endemic caddisfly taxa of Bosnia and Herzegovina (Stanić-Koštroman, 2009). The spring area of the Lištica River is the only currently known population of *D. ramae*, because the spring of the Rama River, the *locus typicus* of this species,

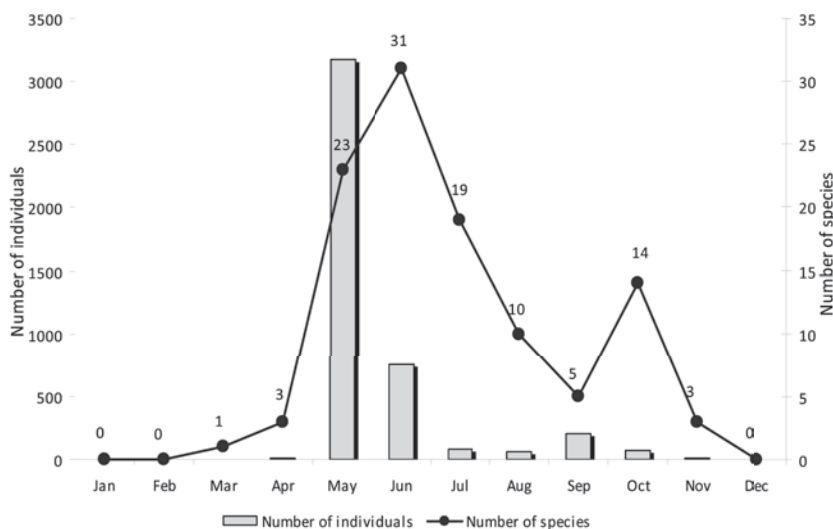


Figure 1. The total number of species and individuals caught at the two sampling sites in the Lištica River.

Table 2. Caddisfly species caught by a light trap at two sites of the Lištica River (L1 – Bilo Vrilo spring, L2 – middle reach of the river) with temporal distribution of each species.

Species	Sampling sites		Flight period
	L1	L2	
<i>Rhyacophila balcanica</i> Radovanović, 1953*	104		29 May – 20 Nov
<i>Rhyacophila fasciata fasciata</i> Hagen, 1859*	41	20	12 Apr – 20 Nov
<i>Rhyacophila loxias</i> Schmid, 1970	5		29 May – 15 Jul
<i>Glossosoma bifidum</i> McLachlan, 1879*	131		12 Apr – 25 Sep
<i>Hydroptila forcipata</i> (Eaton, 1873)*		196	14 May – 17 Sep
<i>Agraylea sexmaculata</i> Curtis, 1834*		114	27 Jun – 17 Sep
<i>Cyrnus trimaculatus</i> (Curtis, 1834)		1	18 Aug
<i>Polycentropus flavomaculatus flavomaculatus</i> (Pictet, 1834)*	7	176	14 May – 29. Aug
<i>Plectrocnemia conspersa conspersa</i> (Curtis, 1834)	24	2	13 Jun – 25 Sep
<i>Lype reducta</i> (Hagen, 1868)		3	27 Jun – 3 Oct
<i>Psychomyia klapaleki</i> Malicky, 1995*		302	14 May – 27 Jun
<i>Tinodes braueri</i> McLachlan, 1878		12	29 May – 19 Oct
<i>Tinodes rostocki</i> McLachlan, 1878*	69		29 May – 27 Jun
<i>Hydropsyche instabilis</i> (Curtis, 1834)		2	29 May – 13 Jun
<i>Hydropsyche mostarensis</i> Klapálek, 1898	3		13 Jun – 15 Jul
<i>Hydropsyche saxonica</i> McLachlan, 1884		22	14 May – 31 Jul
<i>Hydropsyche</i> spp. (females)		9	14 May – 18 Aug
<i>Agrypnia varia</i> Fabricius, 1793		12	13 Jun – 29 Aug
<i>Micrasema minimum</i> McLachlan, 1876	2		13 Jun
<i>Goera pilosa</i> (Fabricius, 1775)*		522	29 Apr – 18 Aug
<i>Silo piceus</i> (Brauer, 1857)*		2178	14 May – 27 Jun
<i>Drusus ramae</i> Marinković, 1970*	149		14 May – 27 Jun
<i>Limnephilus lunatus</i> Curtis, 1834		21	29 May
<i>Limnephilus marmoratus</i> Curtis, 1834		7	29 May
<i>Limnephilus rhombicus rhombicus</i> (Linnaeus, 1758)		43	29 May – 19 Oct
<i>Halesus digitatus digitatus</i> (Schränk, 1781)	3	5	3 Oct – 19 Oct
<i>Micropterna nycterobia</i> (McLachlan, 1875)	1	5	3 Oct – 19 Oct
<i>Micropterna sequax</i> (McLachlan, 1875)	2		13 Jun – 28 Oct
<i>Micropterna testacea</i> (Gmelin, 1790)	1		15 Oct
<i>Potamophylax latipennis</i> (Curtis, 1834)	4		14 May – 13 Jun
<i>Sericostoma flavicorne</i> Schneider, 1845*	50	41	14 May – 15 Jul
<i>Odontocerum albicorne</i> (Scopoli, 1763)	31		14 May – 15 Jul

Table 2. continued

<i>Beraemyia schmidi</i> Botosaneanu, 1960	6	29 May – 13 Jul	
<i>Mystacides azurea</i> (Linnaeus, 1761)	5	27 Jun – 29 Aug	
<i>Ceraclea dissimilis</i> (Stephens, 1836)	2	1	15 Jul – 31 Jul
<b>Number of specimens</b>	<b>629</b>	<b>3705</b>	
<b>Number of species</b>	<b>18</b>	<b>23</b>	

\*abundant species ( $\geq 1\%$  of a total catch)

was completely devastated by the construction of a reservoir during the 1970s (Kučinić et al., 2010). Beside *D. ramae*, two more species caught in the spring of the Lištica – Bilo vrilo: *R. balcanica* and *Hydropsyche mostarensis* Klapálek, 1898 are endemic for the Balkan Peninsula (Stanić-Koštroman, 2009). The documentation of *H. mostarensis* represents the first record for the caddisfly fauna of the Lištica River spring area (Marinović-Gospodnetić, 1979).

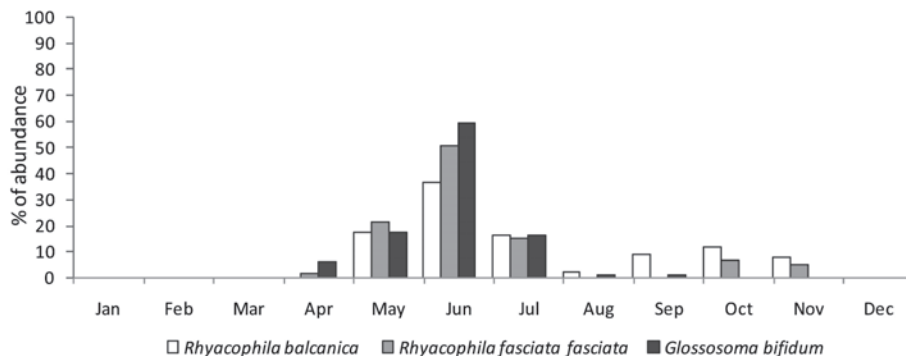
A total of 3705 specimens belonging to 23 species were collected at the site in the middle reach of the Lištica River (Table 2). The most abundant species at this site were *Silo piceus* (Brauer, 1857) and *Goera pilosa* (Fabricius, 1775). These two species accounted for 73 % of the total catch, of which *S. piceus* alone accounted for 59 %. *Agraylea sexmaculata* Curtis, 1834 is recorded for the first time in Bosnia and Herzegovina (Stanić-Koštroman, 2009).

The flight patterns of the species collected are shown in Table 2. Adult caddisflies were caught from March to November, with flight peaks observed during the warmer spring/summer months (Fig. 1). The highest number of species was recorded in June (27 species), and the greatest numbers of individuals were light-trapped in May (73 % of the total catch). According to the classifications proposed by Crichton (in Hickin, 1967), *Halesus digitatus digitatus* (Schrank, 1781), *Micropterna nycterobia* (McLachlan, 1875) and *Micropterna testacea* (Gmelin, 1790) are autumn species, with flight periods restricted to October. All others species identified during this study had either spring or summer flight activity (Table 2).

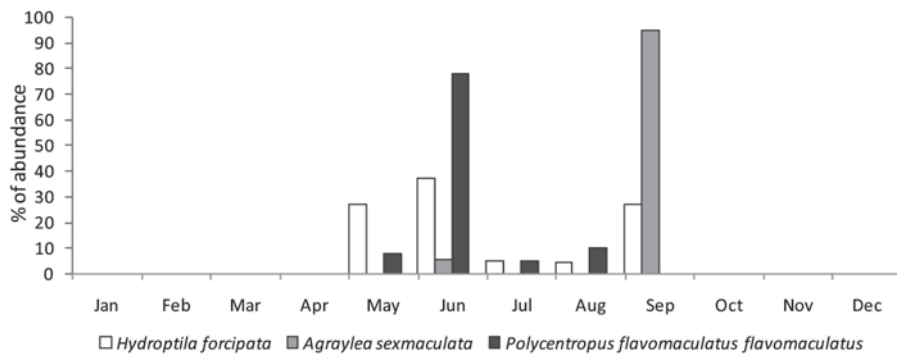
For the most abundant species ( $\geq 1\%$  of a total catch) similar temporal flight patterns were recorded, with catches peaking in summer (Fig. 2a-d). However, in *Agraylea sexmaculata* the maximum number of specimens was caught in September. In most species, a single peak was observed, although in *A. sexmaculata* and *Hydroptila forcipata* (Eaton, 1873) there were two peaks; one in June and a later one in September. Short flying seasons of 3 months or less were recorded

S. STANIĆ-KOŠTROMAN, M. KUČINIĆ, A. KOLOBARA, D. ŠKOBIĆ, L. KNEZOVIĆ & P. DURBEŠIĆ:  
 Light-trapped caddisflies (Insecta: Trichoptera) as indicators of the ecological integrity of the Lištica River,  
 Bosnia and Herzegovina

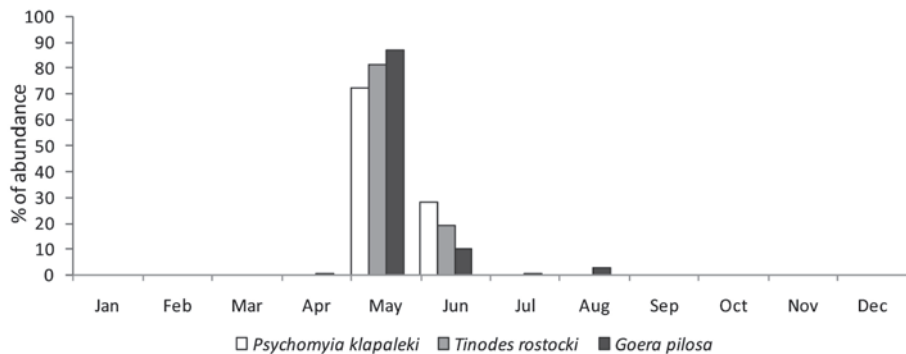
a)



b)



c)





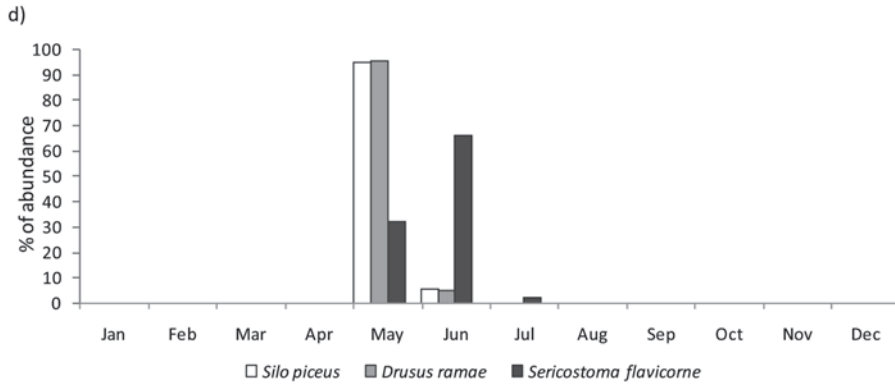
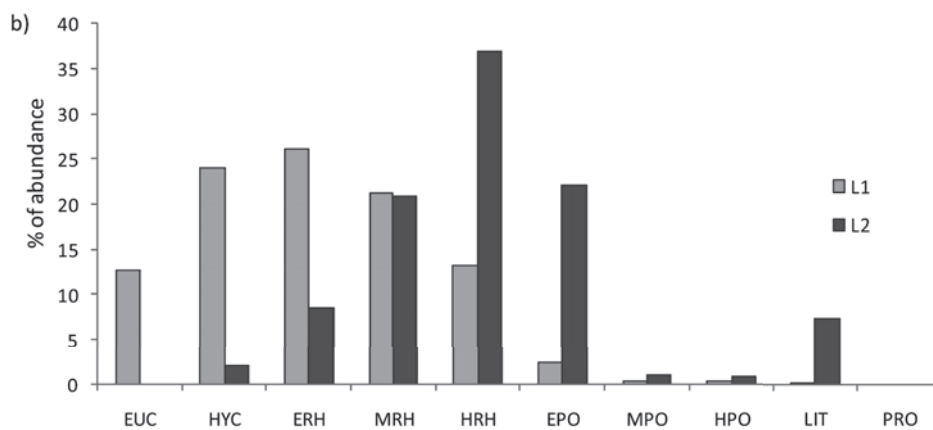
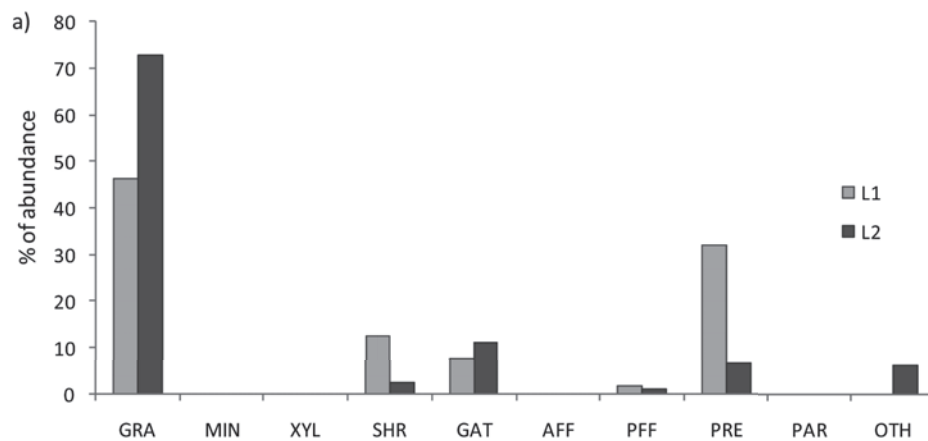


Figure 2. Flight activity of the twelve most abundant species ( $\geq 1\%$  of a total catch) of Trichoptera.

for *Psychomyia klapaleki* Malicky, 1995, *Tinodes rostocki*, McLachlan, 1878, *Silo piceus*, *Drusus ramae* and *Sericostoma flavicorne* Schneider, 1845, whereas the remaining species had flight activities of 4 months or more. The longest flight periods were observed in *Rhyacophila balcanica* and *R. fasciata fasciata* Hagen, 1859. These two species were on the wing for 7 and 8 months, respectively.

Variability in the length of flight periods may be the consequence of the sampling method, or be caused by the differences in the life cycles of species (Collier & Smith, 1998; Petersen et al., 1999; Smith et al., 2002; Waringer, 1989). Diverse life history patterns have evolved to enable species to exploit foods that are seasonably available, to use an appropriate timing for aerial existence, to evade unfavorable conditions or to avoid biotic interaction such as competition and predation (Wallace & Anderson, 1996). A relationship between duration of flight period and feeding behavior of larvae was confirmed by many authors (e.g. Otto, 1981; Previšić et al., 2007; Smith et al., 2002). In this study, caddisflies with predatory or net-spinning larvae (Rhyacophilidae, Polycentropodidae, Hydropsychidae) exhibited extended flight periods. For both these groups food availability (e.g. prey and fine particulate organic matter-FPOM) is relatively constant the whole year through (Otto, 1981). In contrast, reduced flight periods (Psychomyiidae, Goeridae, Limnephilidae, Sericostomatidae) were generally observed in grazers (feeding on algae) or shredders (feeding on fallen leaves), reflecting the season-

S. STANIĆ-KOŠTROMAN, M. KUČINIĆ, A. KOLOBARA, D. ŠKOBIĆ, L. KNEZOVIĆ & P. DURBEŠIĆ:  
Light-trapped caddisflies (Insecta: Trichoptera) as indicators of the ecological integrity of the Lištica River,  
Bosnia and Herzegovina



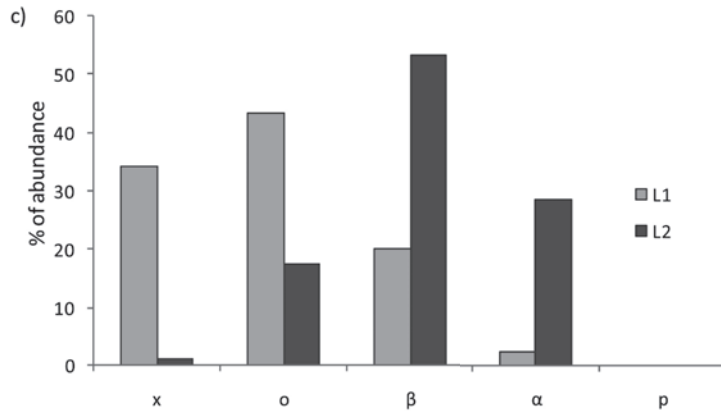


Figure 3. Composition of caddisfly assemblages at two sampling sites at the Lištica River (L1 – spring of the Lištica River; L2 – middle reach of the Lištica River) regarding: (a) Distribution of functional feeding guilds (GRA – grazers, MIN – miners, XYL – xylophagous species, SHR – shredders, GAT – gatherers, AFF – active filter feeders, PFF – passive filter feeders, PRE – predators, PAR – parasites, OTH – other feeding types); (b) Longitudinal zonation preference of caddisflies (EUC – eucrenal, HYC – hypocreanal, ERH – epirhithral, MRH – metarhithral, HRH – hyporhithral, EPO – epipotamal, MPO – metapotamal, HPO – hypopotamal, LIT – littoral, PRO – profundal) and (c) Saprobic valencies based on caddisfly species (x – xenosaprobic, o – oligosaprobic, β – beta-mesosaprobic, α – alpha-mesosaprobic, p – polysaprobic).

nal availability of food resources. According to Otto (1981), the prolonged flight periods recorded for some species of grazers and shredders (e.g. *G. bifidum*, *G. pilosa*, *L. rhombicus rhombicus* (Linnaeus, 1758), *M. sequax* (McLachlan, 1875)) in the current study may be caused by potentially long periods of emergence or adult longevity.

With respect to functional feeding guilds, the caddisfly assemblages at both sampling sites of the Lištica River were dominated by grazers (Fig. 3a). At the Lištica spring grazers accounted for 46 % and were represented mainly by *D. ramae* and *G. bifidum*. Predators represented by *Rhyacophila* species and shredders represented by *S. flavicorne* also accounted for a relatively large proportion of the collection (32 % and 12 %, respectively). In the middle reach of the Lištica River

grazers made up to 73 % of the total catch, reflecting the high proportion of *S. piceus* and *G. pilosa*. The second and third most abundant feeding groups were gatherers (11 %) and predators (7 %).

The composition of functional feeding guilds reflects differences in habitat diversity and the shift in food availability along the river continuum (Vannote et al., 1980). According to the river continuum concept (RCC; Vannote et al., 1980) many headwater streams are strongly affected by the surrounding vegetation, resulting in communities dominated by shredders. However, in unshaded regions, such as the Bilo Vrilo spring area, primary production is not limited by riparian vegetation and grazers are the most abundant feeding group (Previšić et al., 2007; Stanić-Koštroman, 2009; Vannote et al., 1980). Patterns in the longitudinal variation of functional feeding guild composition at two sites of the Lištica River meet the predictions made by the RCC. Caddisfly assemblages at both sampling sites are dominated by grazers, with the proportion increasing downstream. The percentage of shredders declined from the spring to the middle reaches of the river; in contrast, the proportion of gatherers gradually increases, reflecting the shift from coarse to fine particulate organic matter.

The distribution of organisms, resources and biological processes depends on large-scale processes (e.g. climatic, hydrological, geomorphological) as well as local ones (e.g. biotic) (Giller & Malmqvist, 1988; Johnson et al., 2004; Ricklefs, 1987; Wagner et al., 2000). The stream zonation concept (Illies & Botosaneanu, 1963) defines a series of distinct regions along rivers: crenon, rhithron and potamon, mainly according to the distribution of animal species, but also according to temperature, discharge, water velocity and sediment particle size. The longitudinal classification of the Lištica River based on species-specific zonal distribution patterns is shown in Fig. 3b. Using the calculation procedure described by Moog (2002), both sampling sites can be classified as rhithral. At the spring Bilo Vrilo the most abundant were epirhithral species (26 %). Crenal (hypocrenal and eucrenal) species, represented mainly by *D. ramae*, also accounted for high proportions (13 % and 24 %, respectively). In the middle reach of the Lištica the benthic community was dominated by hyporhithral elements (37 %), followed by epipotamal (22 %) and metharhithral (21 %) species. These results fit well with the annual range of minimum and maximum water temperatures and substrate composition (Table 1), which are the most useful abiotic indicators for longitudinal river zones (Moog, 2002).

Over the last decades, light trapping of caddisflies has also been used to monitor water quality. In this study, from among the 34 species collected, 20 species have been classified in saprobic systems (Graf et al, 2002) and were used as indicators of water quality (Fig. 3c). At the spring of the Lištica River 17 % of the species were xenosaprobic and 54 % oligosaprobic; 29 % of the species were also indicative of beta-mesosaprobic and alpha-mesosaprobic conditions (27 % and 2 %, respectively) and may have come from outside the Bilo Vrilo spring area. The calculated saprobic index of the site is 1.16. In the middle reach of the Lištica River beta-mesosaprobic and alpha mesosaprobic species (54 % and 29 %, respectively) were most abundant, with the rest (17 %) consisting of oligosaprobic and xenosaprobic elements. The saprobic index of this site is 2.12.

The results of this study showed that the water quality in the spring of the Lištica River is high, which is in agreement with physico-chemical characteristics of the water. All descriptors of the caddisfly assemblages (species inventory, abundances, longitudinal zonation and composition of functional-feeding guilds) conform to the site-specific reference state, so this site can be qualified as pristine. Since the water is used as drinking water and also because the spring itself is a tourist attraction, nature conservation and environmental protection along with landscape management are indispensable. However, measures of the biotic elements in the middle reach of the Lištica River indicated that the water at this site is moderately polluted. Since the longitudinal and functional feeding group distribution for the most part meet the reference conditions, our results indicate that the Lištica River in Mostarsko Blato can be regarded as slightly to moderately disturbed.

Based on these observations, our findings indicate that light-trapped caddisflies can be used as indicators of the ecological status of water bodies. In order to gain the best insight into community composition and proper allocation of breeding habitats, light traps should ideally be accompanied by other methods, e.g. collection of larvae.

### **Acknowledgments**

We are very grateful to Zdravka Stanić for her assistance with the English and two anonymous reviewers for improving the previous version of the manuscript.

## References

- BONADA, N., ZAMURA-MUÑOZ, C., RIERADEVALL, M. & PRAT, N., 2004. Ecological profiles of caddisfly larvae in Mediterranean streams: Implications for bioassessment methods. *Environmental Pollution*, 132: 509-521.
- BOTOSANEANU, L. & MALICKY, H., 1978. Trichoptera. In: Illies, J. (Ed.), *Limnofauna Europaea*, Gustav Fischer Verlag, pp. 333-359, Stuttgart.
- CHANTARAMONGKOL, P., 1983. Light-trapped caddisflies (Trichoptera) as water quality indicators in large rivers: results from the Danube at Verőce, Hungary. *Aquatic Insects*, 5: 33-37.
- CHATZINIKOLAOU, Y., DAKOS, V. & LAZARIDOU, M., 2008. Assessing the ecological integrity of a major transboundary Mediterranean river based on environmental habitat variables and benthic macroinvertebrates (Aos-Vjose River, Greece-Albania). *International Review of Hydrobiology*, 93: 73-87.
- COLLIER, K. J. & SMITH, B. J., 1998. Dispersal of adult caddisflies (Trichoptera) into forests alongside three New Zealand streams. *Hydrobiologia*, 361: 53-65.
- COLLIER, K. J., SMITH, B. J. & BAILLIE, B. R., 1997. Summer light-trap catches of adult Trichoptera in hill-country catchments of contrasting land use, Waikato, New Zealand. *New Zealand Journal of Marine and Freshwater Research*, 31: 623-634.
- CRICHTON, M. I., FISHER, D. & WOIWOD, I. P., 1978. Life histories and distribution of British Trichoptera, excluding Limnephilidae and Hydroptilidae, based on the Rothamsted Insect Survey. 1: 31-45.
- EUROPEAN UNION, 2000. Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy. *Official Journal of the European Communities L 327*, 22.12.2000, pp. 72, Luxembourg.
- GILLER, P. S. & MALMQVIST, B., 1998. *The biology of streams and rivers*. Oxford University Press, pp. 296, New York.
- GRAF, W., GRASSER, U. & WARINGER, J., 2002. Trichoptera. In: Moog, O. (Ed.), *Fauna Aquatica Austriaca*, Edition 2002, Wasserwirtschaftskataster Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft, pp. 44, Wien.
- GRAF, W., MURPHY, J., DAHL, J., ZAMORA-MUÑOZ, C. & LÓPEZ-RODRÍGUEZ, M. J., 2008. Trichoptera. In: Schmidt-Kloiber, A. & Hering, D. (Eds.), *Distribution and ecological preferences of European freshwater organisms*, Pensoft, pp. 388, Sofia-Moscow.
- HICKIN, N.E., 1967. *Caddis Larvae*. Hutchinsin & Co., pp. 476, London.
- HOLZENTHAL, R. W., BLAHNIK, R. J., PRATHER, A. L. & KJER, K. M., 2007. Order Trichoptera Kirby, 1813 (Insecta), Caddisflies. *Zootaxa*, 1668: 639-698.
- IRMER, U., 2000. The new EC Framework Water Directive: Assessment of the chemical and ecological status of surface waters. *Acta Hydrochimica et Hydrobiologica*, 28: 7-14.

S. STANIĆ-KOŠTROMAN, M. KUČINIĆ, A. KOLOBARA, D. ŠKOBIĆ, L. KNEZOVIĆ & P. DURBEŠIĆ:  
Light-trapped caddisflies (Insecta: Trichoptera) as indicators of the ecological integrity of the Lištica River,  
Bosnia and Herzegovina

- JOHNSON, R. K., GOEDKOP, W. & SANDIN, L., 2004. Spatial scale and ecological relationships between the macroinvertebrate communities of stony habitats of streams and lakes. *Freshwater biology*, 49: 1179-1194.
- KREBS, C. J., 1999. *Ecological methodology*. Addison-Welsey Education Publishers, pp. 620, Menlo Park.
- KUČINIĆ, M., PREVIŠIĆ, A., STANIĆ-KOŠTROMAN, S., FRANJEVIĆ, M., ŠERIĆ JELASKA, L., DELIĆ, A. & POSILOVIĆ, H., 2010. Description of the larvae of *Drusus ramae* Mrinković-Gospodnetić and *Drusus medianus* Marinković-Gospodnetić (Trichoptera: Limnephilidae) with some genetic, distributional, ecological, faunal and conservation notes. *Zootaxa*, 2484: 1-24.
- MACKAY, R. J. & WIGGINS, G. B., 1979. Ecological diversity in Trichoptera. *Annual Review of Entomology*, 24: 185-208.
- MALICKY, H., 2004. *Atlas of European Trichoptera*. Springer, pp. 359, Dordrecht.
- MALICKY, H., 2005. Ein kommentiertes Verzeichnis der Köcherfliegen (Trichoptera) Europas und des Mediterrangebietes. *Linzer Biologische Beiträge*, 37: 533-596.
- MALICKY, H. & CHANTARAMONGKOL, P., 1993. The altitudinal distribution of Trichoptera species in Mae Klang catchment on Doi Inthanon, northern Thailand: stream zonation and cool- and warm-adopted groups. *Revue d'Hydrobiologie Tropicale*, 26(4): 279-291.
- MARINKOVIĆ-GOSPODNETIĆ, M., 1979. Trichoptera (Insecta) velikih karstnih izvora u Dinaridima. In: Rauš, Đ. (Ed.), *Drugi kongres Ekologa Jugoslavije (Second Congress of Ecologists of Yugoslavia)*, Savez društava ekologa Jugoslavije, pp. 1837-1849, Zagreb.
- MILIĆEVIĆ, M., 2009. Socio-geographic transformation of Mostarsko Blato. *Geoadria*, 14/1: 27-59.
- MOOG, O. (editor), 2002. *Fauna Aquatica Austriaca, Edition 2002*. Wasserwirtschaftskataster Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft, pp. 684, Wien.
- MORSE, J. C., 2003. Trichoptera (caddisflies). In: Resh, V. H & Card, R. T. (Eds.), *Encyclopedia of Insects*, Academic Press, pp. 1145-1151, New York.
- OLIVIERA, S. V. & CORTES, M. V., 2006. Environmental indicators of ecological integrity and their development for running waters in northern Portugal. *Limnetica*, 25(1-2): 479-498.
- OTTO, C., 1981. Why does duration of flight periods differ in caddisflies? *Oikos*, 37: 383-386.
- PETERSEN, I., MASTERS, Z., HILDREW, A. G. & ORMEROD, S. J., 2004. Dispersal of adult aquatic insects in catchment of differing land use. *Journal of Applied Ecology*, 41: 934-950.
- PETERSEN, I., WINTERBOTTOM, J. H., ORTON, S., FRIBERG, N., HILDREW, A. G., SPIERS, D. C. & GURNEY, W. S. C., 1999. Emergence and lateral dispersal of adult Plecoptera and Trichoptera from Broadstone Stream, UK. *Freshwater Biology*, 42: 401-416.
- PREVIŠIĆ, A., KEROVEC, M. & KUČINIĆ, M., 2007. Emergence and composition of Trichoptera from karst habitats, Plitvice Lakes region, Croatia. *International Review of Hydrobiology*, 92: 61-83.
- RICKLEFS, R. E., 1987. Community diversity: relative roles of local and regional processes. *Science*, 235: 167-171.

S. STANIĆ-KOŠTROMAN, M. KUČINIĆ, A. KOLOBARA, D. ŠKOBIĆ, L. KNEZOVIĆ & P. DURBEŠIĆ:  
Light-trapped caddisflies (Insecta: Trichoptera) as indicators of the ecological integrity of the Lištica River,  
Bosnia and Herzegovina

- SCHMERA, D., 2003. Light trap-collected caddisfly (Insecta: Trichoptera) assemblages reflect altitude. *Community Ecology*, 4(2): 233-236.
- SMITH, B. J., COLLIER, K. J. & HALLIDAY, N. J., 2002. Composition and flight periodicity of adult caddisflies in New Zealand hill-country catchments of contrasting land use. *New Zealand Journal of Marine and Freshwater Research*, 36: 863-878.
- STANIĆ-KOŠTROMAN, S., 2009. Faunal, ecological and biogeographical characteristics of caddisflies (Insecta: Trichoptera). PhD Thesis (in Croatian), University of Zagreb. pp. 139.
- SVENSSON, B. W., 1972. Flight periods, ovarian maturation, and mating in Trichoptera at South Swedish stream. *Oikos*, 23: 370-383.
- SVENSSON, B. W., 1974. Population movements of adult Trichoptera at a South Swedish stream. *Oikos*, 25: 157-175.
- TALIĆ, S., MARTINOVIĆ, A. & DURBEŠIĆ, P., 2007. Kemijska analiza vodotoka Rijeka Radobolje i Lištice. In: Bogut, I. (Ed.), *Uzgoj riba u hidroakumulacijama, mogućnost upravljanja i zaštita okoliša*, Agronomski fakultet Sveučilišta u Mostaru, pp. 383-392, Mostar.
- TSURUISHI, T., 2003. Life cycle of a giant carnivorous caddisfly, *Himalopsyche japonica* (Morton) (Trichoptera: Rhyacophilidae), in the mountain streams of Nagano, Central Japan. *Limnology*, 4: 11-18.
- VANNOTE, R. L., MINSHALL, G. W., CUMMINS, K. W., SEDELL, J. R. & CUSHING, C. E., 1980. The river continuum concept. *Canadian Journal of Fisheries and Aquatic Sciences*, 37: 130-137.
- WAGNER, R., DAPPER, T. & SCHMIDT, H. H., 2000. The influence of environmental variables on the abundance of aquatic insects: a comparison of ordination and artificial neural networks. *Hydrobiologia*, 422/423: 143-152.
- WALLACE, J. B. & ANDERSON, N. H., 1996. Habitat, life history and behavioral adaptations of aquatic insects. In: Merritt, R. W. & Cummins, K. W. (Eds.), *An introduction to the aquatic insects of North America*, Kendall/Hunt Publishing, pp. 41-73, Dubuque.
- 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. *Freshwater Biology*, 21: 387-399.
- WARINGER, J. A., 2003. Light-trapping of caddisflies at the Thaya (Lower Austria), a river influenced by pulsating hypolimnetic water release. *International Review of Hydrobiology*, 88: 139-153.
- WARINGER, J. & GRAF, W., 2006. Light-trapping of Trichoptera at the March, a lowland river in Eastern Austria. *Archiv für Hydrobiologie Supplement*, 158/3: 351-372.
- ZELENIKA, M., SOLDI, B. & ŠTUHEC, D., 2005. The remediation of the adverse effects of the gravel extraction in the Mostarsko Blato catchment area. *International Symposium on Water Management and Hydraulic Engineering*, pp. 524-531, Ottenstein.