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EFFECTS OF DROUGHT ON THE COMPOSITION AND STRUCTURE OF BENTHIC MACROINVERTEBRATE ASSEMBLAGES – A CASE STUDY

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Abstract

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Natural drying up of streams is not common in Central Europe. Nevertheless, the recurrent drying up of small streams in last decades has shown an urgent need to pay attention to the impact of global climate change. This strong disturbance influences conditions in streams markedly and causes changes in the taxonomical and functional structure of biota. The aim of the study was to compare aquatic macroinvertebrate assemblages of one intermittent and one permanent brook in South Moravia. The study was carried out in two stretches with otherwise comparable environmental parameters. Lower densities of macroinvertebrates were found at the intermittent site the difference was statistically significant. The number of taxa and diversity were significantly higher at the permanent site. Functional structure of the assemblages also varied. The shares of rheobionts, grazers and predators differed.

benthic macroinvertebrates, intermittent stream, drought, functional structure, diversity

In this study, we addressed the issue of drying up of small streams. This phenomenon was not typical for the Czech Republic and Central Europe in the past. However, considering the ongoing global climate change, it can be assumed that it will become more frequent in the future. Studies dealing with the effect of natural drought on the aquatic biota are rather scarce in Central Europe (Sommerhäuser & Schuhmacher, 1996; Meyer & Meyer, 2000, Meyer *et al.*, 2003; Pastuchová, 2006; Řezníčková *et al.*, 2007; Řezníčková *et al.*, 2010), but several authors have investigated the influence of fluctuating hydrological regime caused by human activities.

Hydrological regime of watercourses is influenced by various environmental factors (e.g. the character of the catchment, the amount of rainfall and runoff, soil moisture, groundwater level and flow rate etc.) and thus drying up has various reasons (hydrological, climatic or geological). It can be characterized by its frequency, duration of dry and watery period, or by a season in which the watercourses dry up (Lake, 2003).

Based on a combination of physical and biological conditions, Hansen (2001) classified three types of drying streams: perennial, intermittent and ephemeral. In perennial streams water flows during most of the time. These streams dry up only exceptionally in extremely dry years and have a well-defined river bed, in which substrate moves and organic matter does not accumulate (Hansen, 2001). Perennial streams occur on all continents and are common in Europe (Attrill *et al.*, 1996; Wood & Petts 1999; Pinna *et al.*, 2004). Intermittent streams are characterized also by a well-defined river bed, but they dry up in regular cycles, and this disturbance can be predicted (Hansen, 2001; Lake, 2003). Intermittent streams occur on all continents, especially in arid and semi-arid regions of Australia (Closs & Lake, 1994; Hillman & Quinn, 2002; Boulton, 2003), North America (Stehr & Branson, 1938; Delucchi & Peckarsky, 1989; Miller & Golladay, 1996; Rosario & Resh, 2000; Covich *et al.*, 2003; DAHM *et al.*, 2003; Magoulick & Kobza, 2003; Matthews & Marsh-Matthews, 2003; Fritz & Dodds, 2004; Chadwick & Huryn, 2007) or Africa (Arab *et al.*, 2004). Within Europe intermittent stream are often found in the Mediterranean region (Muñoz, 2003; Pinna *et al.*, 2004; Acuña *et al.*, 2005; Bonada *et al.*, 2007; Fenoglio *et al.*, 2007). Ephemeral streams lack stable river-bed, water flow is limited to time periods with extreme rainfall. Organic material does not move or accumulate in ephemeral streams (Hansen, 2001).

Drying up is a disturbance with a crucial impact on both abiotic and biotic factors in aquatic ecosystems. Physico-chemical parameters and biochemical conditions change significantly as the water level decreases; these changes usually include decreasing oxygen saturation, increasing conductivity, deteriorating water quality etc. (Lake, 2003; Larned *et al.*, 2011). Reduced flow velocity and amount of water results in reduced quantity and diversity of habitats and in their changes. The supply of organic matter and basic trophic elements (carbon, nitrogen and phosphorus) from the upper part of the stream is interrupted, the supply of bioavailable carbon, which is important for the metabolism of microorganisms, is reduced (Boulton, 2003; Dahm *et al.*, 2003; Acuña *et al.*, 2005).

Changing conditions significantly affect macroinvertebrate communities. Riffle habitats disappear with decreasing water flow and rheobionts and rheophils loose their living space. Conditions become more lenitic and habitats with slow current and greater depth, which are more suitable for limnobionts tolerating lower oxygen content and water quality, prevail. Drying also causes marked changes in the trophic network of the communities. Formation of isolated pools often leads to a significant increase in the number of predators. Generally, the availability of natural food sources is impaired and competition increases. Interruption of the longitudinal continuum limits migration of organisms from both upstream and downstream parts of the watercourse (Lake, 2003). Benthic invertebrates are adapted to living in water and drying acts as a significant stressor that can eliminate some species from the aquatic ecosystem. Animals that are unable to adapt to adverse conditions or unable to find suitable refugia die. Therefore, abundance and taxonomic composition and functional structure of the community change. The impact on biota and the ecosystem depends on many factors including the presence of refugia (e.g. Rosario & Resh, 2000; Smith & Wood, 2002; Boulton, 2003; Lake, 2003; Magoulick & Kobza, 2003) and also on the extent of the impact of human activities, e.g. river regulation, pollution, water abstraction etc.

Aquatic organisms react to changing conditions in accordance with their characteristics and abilities – they choose different survival strategies (Lake, 2003). Organisms living in habitats with a rather regular hydrological regime usually adapt more easily (Lake, 2003); the same is true for organisms that had the opportunity to adapt over long evolutionary development (Mcmahon & Finlayson, 2003). In this case, the animals can have various physiological and behavioral adaptations or predispositions to survival. Under the conditions of the Czech Republic, macroinvertebrate communities are mostly not adapted to drying from this point of view.

The level of impairment of macroinvertebrate communities depends on local conditions of the disturbed stream and the duration and intensity of drought (Kubíček, 1988). After the dry period, recolonization takes place. Its rate depends on the resistance and resilience of the community. Different recolonization mechanisms exist and usually they are species-specific (Williams & Hynes, 1976). Organisms can colonize re-flooded habitats by drifting from up-stream parts of the watercourse or by active migration from down-stream stretches or hyporheic zone. An important part of the colonization cycle of insect species is the aerial dispersion of egg-laying imagoes. This mechanism is relevant only during the warmer parts of the year and therefore, the recolonization of damaged habitats may be much slower in winter.

Stabilization and full recovery of the communities can take up to three months to several years depending on the extent of the damage, sources in refugia and local conditions (Kubíček, 1978).

Organisms are generally unable to adapt to sudden and unpredictable drying. This type of drying is characterized by low resistance and resilience of organisms (Lake, 2003). Recolonization after such dry episode takes longer. Overall, there are only few papers dealing with non-seasonal and unpredictable drying (Ladle & Bass, 1981; Wood & Petts, 1999; Boulton, 2003; Covich *et al.*, 2003).

The aim of this study was to determine differences between macroinvertebrate communities of one intermittent and one permanent stream. We have assumed that drying is a fundamental disturbance that will be reflected in both taxonomic and functional structure of the communities.

MATERIALS AND METHODS

Study Area

This study was carried out in Granicky and Klaperuv brooks, both stretches are situated in the south of Moravia (Czech Republic) and they are left-hand tributaries of the River Dyje (Thaya), in the Danube Catchment. This region is one of the driest parts of the Czech Republic (average annual rainfall is only 665 mm).

The character of these two brooks is very similar, environmental parameters (e.g. cachment area, discharge, substrate, etc.) are comparable. The distance of both study sites, which are situated in the middle stretches of the streams, is 10.5 km.

Klaperuv brook is permanent. Its total length is 8.5 km and its catchment area is 17.6 km^2. The total length of the Granicky brook is 13 km and its catchment area is 20.5 km^2. The study site is situated within a stretch with a high slope and a cobble-gravel-sand substratum that meanders through a deep wooded valley with minimal organic loading or human impact. This stretch is of an intermittent character. The hydrological regime is typically unstable, with regular summer drying up. The dry period lasted for approximately two weeks in 2002. In the following year 2003, the whole brook dried up, study site was dry for more than 3 months, from mid July to the end of the investigation in October.

Sampling Methods

Samples of macroinvertebrates were taken from April 2002 to May 2003 (8 series). The data set used in this study was obtained as a part of the diploma theses of Department of Botany and Zoology, Masaryk University Brno. Benthic macroinvertebrates were sampled using the PERLA method (CSN 75 7701; Kokeš *et al.*, 2006) that comprised semi-quantitative, multihabitat 3 minute kick samples gathered with a hand net (25 × 25 cm aperture, mesh size 0.5 mm, sack length 75 cm). Samples were collected from an approximately 20 m long, representative stretch of the site and each type of mesohabitat was sampled proportionally to its occurrence. Samples were taken only when both sites were flooded with water.

For the estimation of percentage substratum cover, the following six size categories were used: boulders (> 256 mm), cobbles (64–256 mm), coarse gravel (16–64 mm), fine gravel (2–16 mm), sand (0.1–2 mm) and mud (< 0.1 mm) (Furse *et al.*, 1986).

Basic abiotic parameters were also measured during the sampling occasions, comprising actual air and water temperatures, pH, conductivity, mean stream width and depth. Monthly precipitation data were provided by the Czech Hydrometeorological Institute.

Data Analysis

Both abiotic characteristics and biotic metric values (*e.g.* total abundance, taxonomic richness, Shannon Weaver Diversity Index) of both sites were compared over the whole sampling period using nonparametric Wilcoxon tests for paired samples (Statistica version 7.0. software; StatSoft, Inc. 2009).

The benthic fauna was divided into two groups: permanent (non-insect fauna: Tricladida, Crustacea, Nematoda, Enchytraeidae, Oligochaeta, Hirudinea, Crustacea and Mollusca) and temporary (insect fauna: of Ephmeroptera, Plecoptera, Trichoptera (EPT), Megaloptera, Diptera, and Coleoptera, in the last case including adults). The next step was the analysis of the assemblage functional structure: feeding types, current preferences, stream zonation preferences, saprobity, and microhabitat preferences. Macroinvertebrates were divided into six feeding groups: grazers/scrapers, shredders, gatherers/collectors, filter feeders, predators and others (Moog, 1995).

RESULTS AND DISCUSSION

Abiotic parameters

Drying significantly affects all abiotic factors in streams and subsequently the biota. The main factors significantly affecting local conditions in temporary streams include discharge, water temperature, oxygen content and conductivity (Rocha *et al.*, 2012). Water temperature, pH, and dissolved oxygen were comparable on both studied brooks (Tab. I). Only conductivity and depth showed significant differences.

Generally higher values of water conductivity in both studied brooks are of natural origin and result from the geological conditions (sandy clay sediments and schistose biotic granites with high concentrations of sulphates), nevertheless, higher values in Granicky brook are probably caused by low discharges in summer. Sampling and measurements of physico-chemical parameters were carried out during normal water levels and, therefore, no extreme values were recorded. The character of the channel and the substrate were similar at both studied sites.

Abundance

Drying represents a strong disturbance that may cause significant and long-term changes in the abundance of benthic organisms in streams. Total abundance, taxonomic richness and diversity of both sites were compared using nonparametric Wilcoxon tests for paired samples (Tab. II).

I: *Minimum, maximum and mean values of the main abiotic parameters at each site, computed for the whole sampling period. The values were compared using the nonparametric Wilcoxon paired test.*

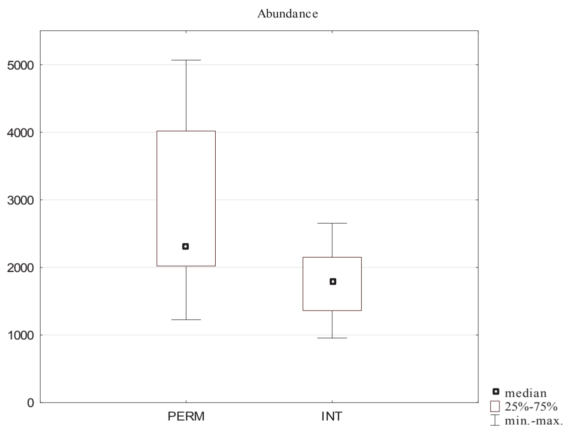
	Permanent brook			Intermittent brook			Wilcoxon test
	MIN	MAX	Mean value	MIN	MAX	Mean value	P-values
Water temperature (°C)	3,0	19,0	11,2	4,0	14,7	9,8	0,116
pH	6,3	7,9	7,3	5,7	8,5	7,6	0,484
Conductivity ($\mu S.cm^{-1}$)	594	692	643	755	930	810	**0,012**
Dissolved oxygen ($mg.l^{-1}$)	8,4	17,4	12,4	9,7	19,5	13,6	0,237
Depth (cm)	7,6	15,2	10,5	2,1	8,6	6,9	**0,018**

II: *Total abundance, taxonomic richness and diversity of both sites were compared using nonparametric Wilcoxon tests for paired samples*

	Z	p-value
Abundance	1.960	0.049
Number of taxa	2.521	0.012
Diversity	2.240	0.025

The numbers of individuals in samples taken from both studied streams were compared and this comparison shows that the abundance of macrozoobenthos was higher in the permanent Klaperuv brook than in the intermittent Granicky brook (Fig. 1), the difference was statistically significant ($p = 0.049$).

The highest abundances were recorded in the Klaperuv brook in summer 2002; at the same time



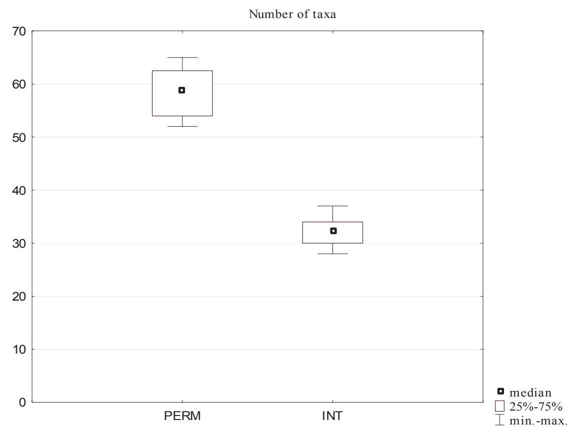
1: *Total abundance of macrozoobenthos in the Klaperuv brook (KB, permanent site) and the Granicky brook (GB, intermittent site)*

abundances were very low in the Granicky brook, probably due to low water level. Regular drying can have lasting effects on benthic communities. Most studies show significantly lower abundances of macroinvertebrates in intermittent streams (Rosario & Resh, 2000; Shivoga, 2001; Smith & Wood, 2002; Smith *et al.*, 2003; Řezníčková *et al.*, 2007). Arab *et al.* (2004) even found extremely low abundances in intermittent streams in North Africa. On the other hand, some authors did not find significant differences between macrozoobenthos abundance in temporary and permanent streams (Legier & Tallinn, 1973; Miller & Golladay, 1996). This inconsistency may be caused by local conditions and the different character and extent of drying.

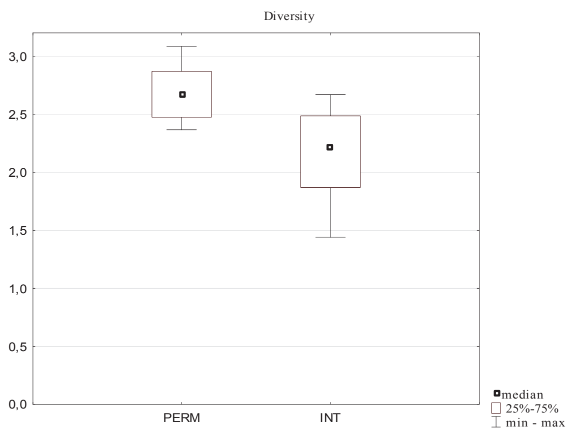
Usually there are greater oscillations in the total abundance during the year at intermittent sites if compared to permanent locations. Abundance often decreases with the decreasing water level before complete drying (Fritz & Dodds, 2004; Muñoz, 2003), and the highest abundances are usually recorded during greater discharge (Pastuchová, 2006; Řezníčková, 2007). In case of slow progressive drying, the stream gradually becomes discontinuous and isolated pools form. Benthic invertebrates can accumulate in these pools and paradoxically the abundance may significantly increase at such habitats. This phenomenon was observed at the study site in Granicky brook during the following research in 2005 and 2007 (undpublished data).

Taxa richness

Several authors compared the number of taxa in intermittent and permanent streams and their results vary. Most authors noted that the number of taxa is negatively affected by drying and, therefore, usually significantly lower in intermittent streams (Wright *et al.*, 1984; Miller & Golladay, 1996; Rosario & Resh, 2000; Muñoz, 2003; Smith *et al.*, 2003; Wood *et al.*, 2005). On the other hand some authors observed lower numbers of taxa only immediately after drying (Boulton, 1989; Griswold *et al.*, 2008). Muñoz (2003) recorded low numbers of taxa before drying, but high in the autumn after re-flooding. In contrast to these results, other authors recorded similar numbers of taxa in permanent and



2: *The number of taxa in the Klaperuv brook (PERM - permanent site) and the Granicky brook (INT - intermittent site)*



3: *Diversity in the Klaperuv brook (PERM - permanent site) and the Granicky brook (INT -, intermittent site)* temporary streams (Legier & Tallinn, 1973; Boulton & Suter, 1986; Miller & Golladay, 1996; Bonada *et al.*, 2007).

In our case study, the number of taxa was higher in the permanent stream (Fig. 2) and this difference was statistically significant (p = 0.012).

Diversity (Shannon-Wiever) was also significantly higher (p = 0.025) in the Klaperuv brook at all sampling dates (Fig. 3).

The total number of taxa was almost twice higher in Klaperuv brook (117 taxa) if compared to Granicky brook (only 67 taxa). The lowest number of taxa was recorded at the intermittent site in autumn (i.e. in the first samples collected after drying). Comparing to oscillations on intermittent site no trends or greater fluctuations in the number of taxa were recorded in the permanent Klaperuv brook.

Taxonomic composition

Disturbances usually negatively affect taxonomic composition of macroinvertebrate assemblages. Regardless of the abundance or the number of taxa, taxonomic composition was different at both studied sites. Appendix gives the list of recorded taxa. Only 30 taxa were found at both sites (e.g. *Gammarus fossarum*, *Micropsectra* sp., *Plectrocnemia conspersa*, *Baetis rhodani*). The freshwater shrimp *G. fossarum* was most abundant in both streams and eudominant in almost all samples. Lower numbers were recorded only in samples collected at the intermittent site during summer just before drying. A total of 55 taxa were found only in Klaperuv brook (e.g. *Brillia flavifrons*, *Baetis muticus*, *Hydropsyche* sp.); and 37 taxa were exclusively found in the intermittent Granicky stream (e.g. *Chaetopteryx* sp., *Isoperla tripartita, Amphinemoura sulcicolis*). In contrast to our findings, Beche *et al.* (2006) reported similar structure and composition of macrozoobenthos communities in intermittent and perennial streams. They found that most taxa were common for both stream types, nevertheless, more unique taxa occurred in intermittent streams.

Larvae of family Chironomidae (especially *Micropsectra* sp., *Tanytarsus* sp.) were abundant in the Granicky brook in summer before drying. This group is often abundant in intermittent streams (Muñoz, 2003; Arab *et al.*, 2004; Rocha *et al.*, 2012). Some of its representatives such as the genus *Polypedilum* are able to produce drought-resistant cocoons (Griswold *et al.*, 2008). *Baetis rhodani* (Ephemeroptera) is also regularly reported from intermittent streams (Bohle, 2000; Meyer & Meyer, 2000; Meyer *et al.*, 2003; Pastuchová, 2006). This species is unable to survive dry periods and has no drought-resistant stages. It occurs in intermittent streams because it is an ubiquist and a good colonizer with a flexible life cycle. *Habrophlebia fusca* is another mayfly species that commonly occurs in intermittent streams in Europe (Bohle, 2000; Meyer & Meyer, 2000; Meyer *et al.*, 2003; Acuña *et al.*, 2005; Buffagni *et al.*, 2007; Sarriquet *et al.*, 2007). This species survives dry periods in the form of drought-resistant eggs (Buffagni *et al.*, 2007). In some intermittent streams other mayfly species were recorded, e.g. *Electrogena* cf. *ujhelyii* (Meyer *et al.*, 2003; Pastuchová, 2006) or *Siphlonurus aestivalis*, which is considered to be an indicator of intermittent streams due to its flexible life cycle, rapid larval development and egg or larval diapause (Bohle, 2000).

Some Trichoptera species are also regularly found in intermittent streams, e.g. carnivorous larvae of *Plectrocnemia conspersa* (Sommerhäuser *et al.*, 1996; Meyer & Meyer, 2000; Meyer *et al.*, 2003; Pastuchová, 2006; Stubbington *et al.*, 2009) that are able to colonize temporary water habitats and are often regarded as indicators of intermittent streams (Sommerhäuser *et al.*, 1996; Bohle, 2000), or *Micropterna nycterobia* (Bohle 2000, Meyer & Meyer, 2000; Meyer *et al.*, 2003; Pastuchová, 2006,). *M. sequax*, which belongs to typical inhabitants of karst intermittent streams in Germany (Meyer & Meyer, 2000; Meyer *et al.*, 2003) and England (Smith & Wood, 2002; Wood *et al.*, 2005; Stubbington *et al.*, 2009).

Remarkably few representatives of Plecoptera were recorded at the intermittent site in the Granicky brook. In the Klaperuv brook, stoneflies were more abundant and a higher number of taxa was recorded (cf. Appendix). According to present knowledge, Ephemeroptera and Trichoptera are much more common in temporary waters compared with Plecoptera (Williams, 1996).

Functional structure

Not only the abundance and taxonomic composition of the macroinvertebrate communities but also their functional structure can be significantly impaired by drying. However, a few studies have dealt with the functional and structural response of aquatic communities to drought (Boulton & Lake, 1992; Wood & Petts, 1999; Churchel & Batzer, 2006; Bonada *et al.*, 2007; Griswold *et al.*, 2008). Therefore, we analyzed the functional structure of the communities from both studied streams and focused on the representation of species living temporarily or permanently in the aquatic environment, current preferences and feeding groups (Tab. III).

Permanent and temporary fauna

Species living permanently in water (permanent fauna) should logically be more affected by drying if compared to species that depend on water for only a certain part of their life cycle (temporary fauna, typically insects) and have the opportunity to complete their development in the aquatic environment before the stream dries up. Generally, these species are also able to colonize reflooded habitats faster.

The proportion of permanent a temporary fauna fluctuated at both studied localities during the sampling season; greater fluctuations were recorded in the intermittent Granicky brook. Permanent fauna, represented mainly by *Gammarus fossarum*, mostly prevailed in the Granicky brook, but its

III: *Comparison of permanent versus temporary fauna, current preferences and feeding types - both sites were compared using nonparametric Wilcoxon tests for paired samples*

		Z	p- value
Permanent versus temporary fauna	permanent	0,56	0,575
	temporal	**1,96**	**0,05**
Current preferences	limnophil	0,14	0,889
	limnorheophil	1,68	0,093
	rheolimnophil	1,26	0,208
	rheophil	1,4	0,161
	rheobiont	**2,366**	**0,018**
Feeding type	grazers/scrapers	**2,38**	**0,017**
	shredders	0,28	0,779
	gatherers/collectors	0,14	0,889
	filter feeders	1,82	0,069
	predators	0	1

proportion decreased markedly in summer before drying. Pastuchová (2006) recorded significant decrease in the number of temporary fauna representatives in Slovak streams during summer when drying typically occurs. However, this decrease may be the result of natural life cycles of insects and may not necessarily be related to drying. Temporary fauna prevailed in the permanent Klaperuv brook. During summer its dominance was even more marked as, similarly to the Granicky brook, the share of permanent fauna (*G. fossarum*) was very low. When comparing the two studied streams, no significant difference in the number of the representatives of permanent fauna was recorded (p = 0.575), but lower share of temporary fauna was recorded in the intermittent Granicky brook and this difference was statistically significant (p = 0.050). Other authors, on the contrary, reported the superiority of the representatives of temporary fauna at intermittent locations (e.g. Smith & Wood, 2002).

Current preferences

At both studied localities rheobionts and rheophils prevailed, which corresponds to the nature of both streams and their hydrological regime. There were no significant differences in the shares of limnorheobionts, rheolimnobionts and rheophils between the two sites. Significant difference were recorded for rheobionts (p = 0.018), which were missing at the intermittent site, probably due to drying. With the decreasing water, level riffle habitats gradually disappear and isolated pools are formed. This process is connected with the loss of living space for rheobionts and rheophils. Under such conditions limnobionts dominate as the remaining aquatic habitats represent lenitic environment in which survivors and new colonizers gather. Stream continuity is interrupted and the migration of organisms (both downstream drift and upstream active movement) is no longer possible (Lake, 2003). Fluctuating hydrological regime is not suitable for rheobiont species that require faster current and high oxygen content. Generally, taxa with pool-like strategies dominate in intermittent streams (Bonada *et al.*, 2007).

Feeding groups

The trophic network in benthic assemblages changes during drying up as the competition for natural food sources increases. The supply of organic matter from the upper parts of drying streams is interrupted; the loss of riffle habitats with coarse and stable substrate leads to the disappearance of filtrators and scrapers. Isolated pools are more suitable for gatherers or (if there is enough of coarse organic matter) for shredders.

When comparing the relative representation of feeding groups at both studied sites, only the share of grazers/scrapers was significantly different (p = 0.017). Shredders represented mainly by *G. fossarum* prevailed in most samples collected at the intermittent site and collectors/gatherers were also abundant there. In summer the share of shredders dramatically decreased for the benefit of collectors/gatherers. The same conclusion was reached by scientists during the research of intermittent streams in Italy (Fenoglio *et al.*, 2007). The share of predators increased just before complete drying, which is a common phenomenon linked to the abundance of prey (Muñoz, 2003). Isolated pools and dry stream bottom are quickly colonized by a large number of predators, both aquatic (Heteroptera, Coleoptera, etc.) and terrestrial (spiders, ants, beetles, amphibians and birds). In the Klaperuv brook the shares of feeding groups were more or less stable throughout the year; gatherers/collectors, grazes/scrapes and shredders prevailed.

Appendix

			PERM	INT
Tricladida	*Dugesia gonocephala*	(Dugès, 1830)	+	-
Mollusca	*Galba truncatula*	(Müller, 1774)	+	+
	Pisidium casertanum	(Poli, 1791)	+	+
	Pisidium personatum	Malm, 1855	+	-
	Pisidium subtruncatum	Malm, 1855	+	-
	Bythinella austriaca	(Frauenfeld, 1857)	-	+
Oligochaeta	*Aulodrilus pluriseta*	(Piguet, 1906)	+	-
	Criodrilus lacuum	Hoffmeister, 1845	+	-
	Eiseniella tetraedra	(Savigny, 1826)	-	+
	Fridericia sp.	Folli, 1658	+	-
	Limnodrilus hoffmeisteri	Claparede, 1862	+	-
	Limnodrilus sp.		-	+
	Lumbriculus variegatus	(Müller, 1774)	+	-
	Nais communis	Piguet, 1906	+	-
	Nais elinguis	Müller, 1773	+	+
	Pristina aequiseta	Bourne, 1891	+	-
	Pristina longiseta	Ehrenberg, 1828	+	-
	Pristina rosea	(Piguet, 1906)	+	-
	Psammoryctides barbatum	(Grube, 1861)	-	+
	Stylodrilus parvus	(Hrabe & Cernosvitov, 1927)	-	+
	Stylodrilus brachystylus	Hrabe, 1928	+	-
	Stylodrilus heringianus	Claparede, 1862	+	+
	Tubificidae g.sp.juv.		+	+
	Rhyacodrilus sp.		-	+
Hirudinea	*Erpobdella octoculata*	(Linnaeus, 1758)	+	-
	Glossiphonia complanata	(Linnaeus, 1758)	+	-
	Haemopis sanguisuga	(Linnaeus, 1758)	+	-
Crustacea	*Gammarus fossarum*	Koch, in Panzer, 1835	+	+
	Gammarus roeselii	(Gervais, 1835)	+	+
Ephemeroptera	*Baetis muticus*	(Linnaeus, 1758)	+	-
	Baetis rhodani	Pictet, 1843–1845	+	+
	Brachyptera risi	(Morton, 1896)	-	+
	Electrogena ujhelyii	(Sowa, 1981)	+	+
	Ephemera danica	Muller, 1764	+	-
	Habroleptoides confusa	Sartori & Jacob, 1986	+	-
	Habrophlebia fusca	(Curtis, 1834)	+	+
	Habrophlebia lauta	Eaton, 1884	+	-
	Paraleptophlebia submarginata	(Stephens, 1835)	+	-
	Paraleptophlebia werneri	Ulmer, 1919	+	-
	Rhithrogena carpatoalpina	(Klonowska *et al.*, 1985)	+	-
	Rhithrogena semicolorata	(Curtis, 1834)	+	-
	Siphlonurus aestivalis	(Eaton, 1903)	-	+
Plecoptera	*Amphinemura sulcicolis*	(Stephens, 1836)	-	+
	Isoperla goertzi	Illies, 1952	+	-
	Isoperla grammatica	(Poda, 1761)	+	-
	Isoperla rivulorum	(Pictet, 1841)	+	-
	Isoperla tripartita	Illies, 1954	-	+
	Leuctra albida	Kempny, 1899	+	-

			PERM	INT
Plecoptera	*Leuctra digitata*	Kempny, 1899	+	-
	Nemoura cambrica	Stephens, 1836	+	-
	Nemoura cinerea	(Retzius, 1783)	+	+
	Nemoura flexuosa	Aubert, 1949	+	-
	Nemurella pictetti	Klapálek 1900	-	+
	Protonemura auberti	Illies, 1954	-	+
Trichoptera	*Protonemura intricata*	(Ris, 1902)	+	-
	Halesus digitatus	(Schrank, 1781)	+	-
	Halesus tesselatus	(Rambur, 1842)	+	-
	Hydropsyche instabilis	(Curtis, 1834)	+	-
	Hydropsyche saxonica	McLachlan, 1884	+	+
	Chaetopteryx fusca/villosa		+	-
	Chaetopteryx maclachlani	Stein, 1874	-	+
	Chaetopteryx major	McLachlan, 1876	+	-
	Ironoquia dubia	(Stephens, 1837)	+	-
	Limnephilus lunatus	Curtis, 1834	-	+
	Lype reducta	(Hagen, 1868)	+	-
	Micropterna nycterobia	(McLachlan, 1875	-	+
	Micropterna sequax	(McLachlan, 1875)	-	+
	Odontocerum albicorne	(Scopoli, 1763)	+	-
	Plectrocnemia conspersa	(Curtis, 1834)	+	+
	Potamophylax cingulatus		+	+
	Potamophylax rotundipennis	(Brauer, 1857)	+	-
	Rhyacophila fasciata	Hagen, 1859	+	-
	Sericostoma sp.		+	+
	Synagapetus moselyi	Ulmer, 1938	-	+
	Stenophylax vibex	(Curtis, 1834)	+	-
	Tinodes rostocki	McLachlan, 1878	+	-
Megaloptera	*Sialis fuliginosa*	Pictet, 1836	+	+
Diptera	*Apsectrotanypus* sp.		-	+
	Apsectrotanypus trifascipennis	(Zetterstedt, 1838)	+	-
	Brillia modesta	(Meigen, 1830)	-	+
	Brillia flavifrons	Johannsen, 1905	+	-
	Ceratopogoninae g. sp.		+	+
	Cladotanytarsus sp.	Kieffer, 1921	+	-
	Corynoneura cf. *celeripes*	Winnertz, 1852	+	-
	Corynoneura lobata	Edwards, 1924	+	-
	Cricotopus tremulus-Gr.		+	-
	Diamesa sp.		+	+
	Dicranota sp.	Zetterstedt, 1838	+	+
	Dixa sp.		+	+
	Empididae g. sp.		+	-
	Epoicocladius flavens	(Malloch, 1915)	+	-
	Eukiefferiella claripennis	(Lundbeck, 1898)	+	-
	Eukiefferiella minor/fittkaui		+	-
	Eukiefferiella sp.		-	+
	Heleniella ornaticollis	(Edwards, 1929)	+	-
	Heleniella sp.		-	+
	Chaetocladius piger-Gr.	(Goetghebuer, 1913)	+	-

			PERM	INT
Diptera	*Chelifera* sp.		+	+
	Limnophila sp.	Macquart, 1834	+	-
	Limnophyes cf. *gurgicola*	(Edwards, 1929)	+	-
	Micropsectra sp.		+	+
	Microtendipes pedellus-Gr.		+	-
	Molophilus sp.	Curtis, 1833	+	-
	Nanocladius rectinervis	(Kieffer, 1911)	+	-
	Natarsia sp.		+	-
	Neolimnomyia batava	(Edwards, 1938)	+	-
	Nilotanypus sp.		+	-
	Odontomyia sp.		-	+
	Orthocladius obumbratus	Johannsen, 1905	+	-
	Orthocladius rubicundus	(Meigen, 1818)	+	-
	Orthocladius sp.	Wulp, 1874	-	+
	Orthocladius thienemanni	Kieffer, in Kieffer, & Thienemann 1906	+	-
	Paracladopelma camptolabis-Gr.		+	-
	Parametriocnemus stylatus	(Kieffer, 1924)	+	-
	Paraphaenocladius sp.		-	+
	Paratrichocladius nivalis	Goetghebuer, 1938	+	-
	Paratrichocladius rufiventris	(Meigen, 1830)	+	-
	Paratrissocladius excerptus	(Walker, 1856)	+	-
	Paratrissocladius sp.		-	+
	Pedicia sp.	Latreille, 1809	+	+
	Pneumia stammeri	Jung, 1956)	+	-
	Polypedilum convictum	(Walker, 1856)	+	-
	Polypedilum laetum-Gr.	(Meigen, 1804)	+	+
	Polypedilum nubeculosum-Gr.		+	-
	Polypedilum pedestre-Agg.		+	-
	Prodiamesa olivacea	(Meigen, 1818)	+	+
	Prosimulium tomosvaryi	(Enderlein, 1921)	+	+
	Psychodidae g. sp.		+	+
	Ptychoptera sp.		+	+
	Rheocricotopus fuscipes	(Kieffer, 1909)	+	-
	Rheocricotopus sp.		-	+
	Rheotanytarsus sp.		+	-
	Scleroprocta sp.	Edwards, 1938	+	-
	Simulium ornatum	Meigen, 1818	+	-
	Simulium vernum	Macquart, 1826	+	-
	Stempellinella sp.		-	+
	Stempellinella brevis-Gr.		+	-
	Stictochironomus sp.		+	-
	Tanytarsus sp.		+	+
	Thienemannia sp.	Kieffer, 1909	-	+
	Thienemanniella cf. *vittata*	(Edwards, 1924)	+	-
	Thienemannimyia Gr., Gen. indet.		+	-
	Tipula maxima	Poda, 1761	-	+
	Tvetenia calvescens	(Edwards, 1929)	+	-
	Tvetenia discoloripes/verralii		+	-
	Zavrelimyia sp.		+	-

			PERM	INT
Coleoptera	*Elmis* sp.		+	+
	Elodes sp. Lv.		+	+
	Hydraena sp. Ad.		+	-
	Limnius sp.		+	-
	Orectochilus villosus Lv.	(Müller, 1776)	+	-
	Platambus maculatus Lv.	(Linnaeus, 1758)	+	-

SUMMARY

The present paper focuses on the impacts of drought on stream macroinvertebrate assemblages. Drying up of watercourses is a strong disturbance that significantly affects both abiotic and biotic conditions in streams. Two brooks in southern Moravia were investigated – the permanent Klaperuv brook, and the intermittent Granicky brook that regularly dries up in summer periods. The study sites were situated only a few kilometres far from each other and except for drying of one of them were very similar. The main objective of the study was to compare the taxonomical and functional structure of the macrozoobenthos communities of both streams. Marked differences between the two assemblages were clearly demonstrated. The total abundance, the number of taxa and diversity were significantly lower in the intermittent Granicky brook. The taxonomic composition of both communities was also different. In total, 151 taxa were recorded, but only 30 taxa were found in both studied streams. 37 taxa were found only in the Granicky brook and 55 taxa were found only in the Klaperuv brook. The two studied communities also differed in their functional structure. The proportion of permanent a temporary fauna fluctuated at both studied localities during the sampling season. When comparing the two streams, no significant difference in the number of the representatives of permanent fauna was recorded, but significantly lower share of temporary fauna was recorded in the intermittent Granicky brook. Rheobionts that require faster current and high oxygen content were completely missing at the intermittent site. Rheophilic and rheolimnephilic species prevailed at both sites, which corresponded with the nature of both streams and their hydrological regime. The trophic network in macroinvertebrate assemblage was also affected by drying. Lower proportions of filtrators and scrapers were recorded in the intermittent stream, but statistically significant difference was observed only in case of grazers/scrapers.

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REFERENCES

ACUÑA, V., MUÑOZ, I., GIORGI, A., OMELLA, M., SABATER, F. & SABATER, S., 2005: Drought and postdrought recovery cycles in an intermittent Mediterranean stream: structural and functional aspects. *Journal of the North American Benthological Society*, 24, 4: 919–933. ISSN 0168-2563.

ARAB, A., LEK, S., LOUNACI, A. & PARK, Y. S., 2004: Spatial and temporal patterns of benthic invertebrate communities in an intermittent river (North Africa). *Annales de Limnologie – International Journal of Limnology,* 40, 4: 317–327. ISSN 0003-4088.

ATTRILL, M. J., RUNDLE, S. D. & THOMAS, R. M., 1996: The influence of drought-induced low freshwater flow on an upper-estuarine macroinvertebrate community. *Water Research*, 30, 2: 261–268. ISSN 0043-1354.

BÊCHE, L. A., McELRAVY, E. P. & RESH, V. H., 2006: Long-term seasonal variation in the biological traits of benthic-macroinvertebrates in two Mediterraneanclimate streams in California, U.S.A. *Freshwater Biology,* 51, 1: 56–75. ISSN 0046-5070.

BOHLE, H. W., 2000: Anpassungsstrategien ausgewählter Organismen an temporäre Wasserführung – Insekten periodischer Fließgewässer Mitteleuropas. In: *Gewässer ohne Wasser?* Westfalen, Recklinghausen: Ökologie, Bewertung, Management temporärer Gewässer; Natur- und Umweltschutz – Akademie des Landes Nordrhein-Westfalen (Hrsg.), NUA-Seminarbericht 5: 53–71. ISBN N.

BONADA, N., RIERADEVALL, M. & PRAT, N., 2007: Macroinvertebrate community structure and biological traits related to flow permanence in Mediterranean river network. *Hydrobiologia,* 589: 91–106. ISSN 0018-8158.

BOULTON, A. J., 1989: Over-summering refuges of aquatic macroinvertebrates in two intermittent streams in central Victoria. *Transactions of the Royal Society of South Australia,* 113: 23–34. ISSN 0372-1426.

BOULTON, A. J., 2003: Parallels and contrasts in the effects of drought on stream macroinvertebrate assemblages. *Freshwater Biology,* 48, 7: 1173–1185. ISSN 0046-5070.

BOULTON, A. J. & LAKE, P. S., 1992: The ecology of two intermittent streams in Victoria, Australia. III. Temporal changes in faunal composition. *Freshwater Biology*, 27, 1: 123–138. ISSN 0046-5070.

BOULTON, A. J. & SUTER, P. J., 1986: Ecology of temporary streams – an Australian perspective. In: de DEKKER P., WILLIAMS, W. D, (eds.), *Limnology in Australia,* Dordrecht: Dr W. Junk Publishers, pp. 313–327. ISSN 0077-0639.

BUFFAGNI, A., ARMANINI, D. G., CAZZOLA, M., ALBA-TERCEDOR, J., LÓPEZ-RODRÍGUEZ, M. J., MURPHY, J., SANDIN L. & SCHMIDT-KLOIBER, A., 2007: Ephemeroptera Indicator Database. Euro-limpacs project (contract No. GOCE-CT-2003-505540), Workpackage 7 – Indicators of ecosystem health, Task 4, www.freshwaterecology.info (version 4.0 -12/2009), (accessed 12/2010).

CHADWICK, M. A. & HURYN, A. D, 2007: Role of habitat in determining macroinvertebrate production in an intermittent-stream system. *Freshwater Biology,* 52, 2: 240-251. ISSN 0046-5070.

CHURCHEL, M. A. & BATZER, D. P., 2006: Recovery of aquatic macroinvertebrate communities from drought in Georgia piedmont headwater streams. *American Midland Naturalist,* 156: 259–272. ISSN 0003-0031.

Closs, G. P. & Lake, P. S., 1994: Spatial and temporal variation in the structure of an intermittent stream food-web. *Ecological Monographs* 64, 1: 1–21. ISSN 0012-9615.

COVICH, A. P., CROWL, T. A. & SCATENA, F. N., 2003: Effects of extreme low flows on freshwater shrimps in perennial tropical stream. *Freshwater Biology,* 48, 7: 1199–1206. ISSN 0046-5070.

CSN 75 7701 Water quality – Methodology for sampling and treatment of macroinvertebrates from running waters using method PERLA. Czech Standards Institute, 2008.

DAHM, C. N., BAKER, M. A., MOORE, D. I. & THIBAULT, J. R., 2003: Coupled biogeochemical and hydrological responses of streams and rivers to drought. *Freshwater Biology*, 48, 7: 1219–1231. ISSN 0046-5070.

DELUCCHI, C. M. & PECKARSKY, B. L., 1989: Life history patterns of insects in an intermittent and a permanent stream. *Journal of the North American Benthological Society*, 8, 4: 308–321. ISSN 0887-3593.

FENOGLIO, S., BO, T., CUCCO, M. & MALACARNE, G., 2007: Response of benthic invertebrate assemblages to varying drought conditions in the Po river (NW Italy). Italian *Journal of Zoology*, 74, 2: 191–201. ISSN 1125-0003.

FRITZ, K. M. & DODDS, W. K., 2004: Resistance and resilience of macroinvertebrate assemblages to drying and flood in a tallgrass prairie stream system. *Hydrobiologia* 527: 99–112. ISSN 0018-8158.

FURSE, M. T., MOSS, D., WRIGHT, J. F., ARMITAGE, P. D. & GUNN, R. J. M., 1986*: A practical manual to the classification and prediction of macroinvertebrate communities in running water in Great Britain*. Freshwater Biological Association. River laboratory, United Kingdom, 147 pp.

GRISWOLD, M. W., BERZINIS, R. W., CRISMAN, T. L. & GOLLADAY, S. W., 2008: Impacts of climatic stability on the structural and functional aspects of macroinvertebrate communities after severe drought. *Freshwater Biology*, 53: 2465–2483. ISSN 0046-5070.

HANSEN, W. F., 2001: Identifying stream types and management implications. *Forest Ecology and Management* 143, 1: 39–46. ISSN 0378-1127.

HILLMAN, T. J. & QUINN, G. P., 2002: Temporal changes in macroinvertebrate assemblages following experimental flooding in permanent and temporary wetlands in an Australian floodplain forest. *River Research and Applications,* 18, 2: 137–154. ISSN 1535-1459.

JOHANSSON, A. & NILSSON, A. N., 1994: Insects of a small aestival stream in northern Sweden. *Hydrobiologia,* 294: 17–22. ISSN 0018-8158.

KOKEŠ, J., ZAHRÁDKOVÁ, S., NĚMEJCOVÁ, D., HODOVSKÝ, J., JARKOVSKÝ, J. & SOLDÁN, T., 2006: The PERLA system in the Czech Republic: A multivariate approach to assess ecological status of running waters. *Hydrobiologia*, 566: 343–354. ISSN 0018-8158.

KUBÍČEK, F., 1978: *Mechanisms of permanent biological activity of running waters*. Brno: UJEP Brno, *Folia Facultatis Scientiarum Naturalium Universitatis Purkinianae Brunensis Biologia,* 64: 33–44. ISSN 0521-2588.

KUBÍČEK, F., 1988: Vliv nulových průtoků na biocenózu toku. *Studia Oecologica*, 1: 27–36. ISSN 1802-212X.

LADLE, M. & BASS, J.A.B., 1981: The ecology of a small chalk stream and its responses to drying during drought conditions. *Archiv für Hydrobiologie*, 90, 4: 448–466. ISSN 0003-9136.

LAKE, P. S., 2003: Ecological effects of perturbation by drought in flowing waters. *Freshwater Biology*, 48, 7: 1161–1172. ISSN 0046-5070.

LARNED, S. T., SCHMIDT, J., DATRY, T. K., KONRAD, C. P., DUMAS, J. K., DIETTRICH, J. C., 2011: Longitudinal river ecohydrology: flow variation down the lengths of alluvial rivers. *Ecohydrology*, 4, 4: 532–548. ISSN 1936-0584.

LEGIER, P. & TALIN, J., 1973: Comparison de ruisseaux permanents et temporaires de la Provence calcaire, *International Journal of Limnology*, 9, 3: 273–292. ISSN 0003-4088.

MAGOULICK, D. D. & KOBZA, R. M., 2003: The role of refugia for fishes during drought: a review and synthesis. *Freshwater Biology,* 48, 7: 1186–1198. ISSN 0046-5070.

MATTHEWS, W. J. & MARSH-MATTHEWS, E., 2003: Effects of drought on fish across axes of space, time and ecological complexity. *Freshwater Biology*, 48, 7: 1232–1253. ISSN 0046-5070.

McMAHON, T. A. & FINLAYSON, B. L., 2003: Droughts and anti-droughts: the low flow hydrology of Australian rivers. *Freshwater Biology*, 48, 7: 1147–1160. ISSN 0046-5070.

MEYER, A. & MEYER, E I., 2000: Discharge regime and the effect of drying on macroinvertebrate communities in a temporary karst stream in East Westphalia (Germany). *Aquatic Science*, 62, 3: 216–231. ISSN 1015-1621.

MEYER, A., MEYER, E. I. & MEYER, CH., 2003: Lotic communities of two small temporary karstic stream systems (East Westphalia, Germany) along a longitudinal gradient of hydrological intermittency. *Limnologica*, 33, 4: 271–279. ISSN 0075-9511.

MILLER, A. M. & GOLLADAY, S. W., 1996: Effects of spates and drying on macroinvertebrate assemblages of an intermittent and perennial prairie stream. *Journal of North American Benthological Society*, 15, 4: 670–689. ISSN 0887-3593.

MOOG, O., (ed.) 1995: *Fauna aquatica Austriaca*. Wien: Lieferung Mai/95. Wasserwirtschaftskataster, Bundesministerium für Land – und Fortwirtschaft. ISBN 3-85174-044-0.

MUÑOZ, I., 2003: Macroinvertebrate community structure in an intermittent and permanent Mediterranean streams (NE Spain). *Limnetica*, 22, 3–4: 107–116. ISSN 0213-8409.

PASTUCHOVÁ, Z., 2006: Macroinvertebrate assemblages in conditions of lowdischargestreams of the Cerová vrchovina highland in Slovakia. *Limnologica*, 36, 4: 241–250. ISSN 0075-9511.

PINNA, M., FONNESU, A., SANGIORGIO, F. & BASSET, A., 2004: Influence of summer drought on spatial patterns of resource availability and detritus processing in Mediterranean stream sub-basins (Sardinia, Italy). *International Review of Hydrobiology*, 89, 5–6: 484–499. ISSN 1434-2944.

ROCHA, L. G., MEDEIROS, E. S. F., ANDRADE, H. T. A., 2012: Influence of flow variability on macroinvertebrate assemblages in an intermittent stream of semi-arid Brazil. *Journal of Arid Environments*, 85: 33–40. ISSN 0140-1963.

ROSARIO, R. B. & RESH, V. H., 2000: Invertebrates in intermittent and perennial streams: is the hyporheic zone a refuge from drying? *Journal of the North American Benthological Society*, 19, 4: 680–696. ISSN 0887-3593.

ŘEZNÍČKOVÁ, P., PAŘIL, P. & ZAHRÁDKOVÁ, S., 2007: The ecological effect of drought on the macroinvertebrate fauna of a small intermittent stream – an example from the Czech Republic. *International Review of Hydrobiology*, 92, 4–5: 514–526. ISSN 1434-2944.

ŘEZNÍČKOVÁ, P., SOLDÁN, T., PAŘIL, P. & ZAHRÁDKOVÁ, S., 2010: Comparison of mayfly (Ephemeroptera) taxocenes of permanent and intermittent Central European small streams via species traits. *Biologia*, 65, 4: 720–729. ISSN 0006-3088.

SARRIQUET, P. E., BORDENAVE, P. & MARMONIER, P., 2007: Effects of bottom sediment restoration on interstitial habitat characteristics and benthic macroinvertebrate assemblages in a headwater stream. *River Research and Applications*, 23, 8: 815–828. ISSN 1535-1459.

SHIVOGA, W. A., 2001: The influence of hydrology on the structure of invertebrate communities in two streams flowing into Lake Nakuru, Kenya. *Hydrobiologia*, 458: 121–130. ISSN 0018-8158.

SMITH, H. & WOOD, P. J., 2002: Flow permanence and macroinvertebrate community variability in limestone spring systems. *Hydrobiologia*, 487: 45–58. ISSN 0018-8158.

SMITH, H., WOOD, P. J. & GUNN, J., 2003: The influence of habitat structure and flow permanence on invertebrate communities in karst spring systems. *Hydrobiologia*, 510: 53–66. ISSN 0018-8158.

SOMMERHÄUSER, M. R. & SCHUHMACHER, H., 1996: Flight periods and life strategies of caddisflies in temporary and permanent woodland brooks in the Lower Rhine Area (Germany). In: *Proc. 8 th Int. Symp. Trichoptera* 1995. Minneapolis, St. Paul, 425–433.

StatSoft Inc., 2009: Statistica (data analysis software system), version 9.0. (http://www.statsoft.com).

STEHR, W. C. & BRANSON, J. W., 1938: An ecological study of an intermittent stream. *Ecology*, 19, 2: 294–310.

STUBBINGTON, R., GREENWOOD, A.M., WOOD, P. J., ARMITAGE, P. D., GUNN, J. & ROBERTSON, A. L., 2009: The response of perennial and temporary headwater stream invertebrate communities to hydrological extremes. *Hydrobiologia* 630: 299–312. ISSN 0018-8158.

WILLIAMS, D. D., 1996: Environmental constraints in temporary fresh waters and their consequences for the insect fauna. *Journal of the North American Benthological Society*, 15, 4: 634–650. ISSN 0887-3593.

WILLIAMS, D. D. & HYNES, H. B. N., 1976: The recolonization mechanisms of stream benthos. *Oikos*, 2, 2: 265–272. ISSN 0030-1299.

WOOD, P. J. & PETTS, G. E., 1999: The influence of drought on chalk stream macroinvertebrates. *Hydrological Processes*, 13, 3: 387–399. ISSN 0885-6087.

WOOD, P. J., GUNN, J., SMITH, H. & ABAS-KUTTY, A., 2005: Flow permanence and macroinvertebrate community diversity within groundwater dominated headwater streams and springs. *Hydrobiologia* 545: 55–64. ISSN 0018-8158.

WRIGHT, J. F., HILEY, P. D., COOLING, D. A., CAMERON, A. C., WIGHAM, M. E. & BERRIE, A. D., 1984: The invertebrate fauna of a small chalk stream in Berkshire, England, and the effect of intermittent flow. *Archiv für Hydrobiologie*, 99, 2: 176–199. ISSN 0003-9136.

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