Distribution and structure of Trichoptera assemblages in the ecoregion "Hungarian lowland" in Slovenia

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Introduction

The understanding of distribution patterns in communities is one of the main aims in ecology (Begon et al. 1996). Several factors, measured at multiple-scale, influence these distribution patterns (Poff 1997). The relative effect may vary according to the spatial scale of the study. In large-scale studies history may be important, whereas in small-scale studies patterns can be explained by environmental variables alone (Townsend et al. 2003, Urbanič 2004). The main objectives of this study are to determine environmental key variables for caddisfly distribution and to identify the major species groups typical for rivers of the Hungarian lowland in Slovenia.

Study area

The study rivers are located in eastern Slovenia, which, according to Illies' (1978) set of ecoregions lies in ecoregion 5 – the Dinaric Western Balkan. However, for the needs of the implementation of the Water Framework Directive (EU, 2000) new delineations of the ecoregions were made in Slovenia (Urbanič 2005). According to this new system, which was used in this study, the eastern part of Slovenia belongs to ecoregion 11 (Hungarian lowland).

Methods

Caddisflies

A total of 163 semi-quantitative samples were taken at 33 sampling sites between 1998 and 2002 as a part of the Slovene national water quality monitoring program. Sampling sites were selected at fourth to seventh stream orders with catchment areas between 173 km^2 and 15379 km^2. Identifications were based mainly on Waringer & Graf (1997) and Urbanič et al. (2003a, b). In addition, pupae and some larvae were reared to emerge in the laboratory and identified in the adult stage.

Environmental variables

Altogether 194 environmental variables were recorded at multiple-spatial scale. These included hydro-morphological (e.g. current speed, water depth, discharge, river regime, stream width, human impact on hydromorphology), geological and physico-chemical variables. For each physico-chemical variable the minimum, maximum, mean and range recorded over 5 years were calculated. A summary of all variables recorded can be found in Urbanič (2004).

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Data analysis

Caddisfly abundance data were transformed to log abundance classes. Only species were included in the analysis. Quantitative environmental variables were transformed to approximate normality. Logarithmic, square root and arc sinh transformations were used.

The caddisfly data set was ordinated by canonical correspondence analysis (CCA) using the program CANOCO 4.0 (Ter Braak & Šmilauer 1998). For forward selected variables the contribution to the explained variance before and after forward selection was calculated. Variance explained before forward selection equals the first eigenvalue of the ordination when each variable is introduced into the ordination as the only environmental variable present. In Table 1 explained variances are calculated as quotient between eigenvalue and total inertia. With forward selection 26 variables were selected. Environmental variables with the highest explained variances are listed in the Table 1.

Table 1. Explained variances of the taxa matrix of main (explained variance > 3.0 %, P = 0.001) environmental variables before and after forward selection (FS).

Environmental variable	**Explained variance (%) before FS**	**Explained variance (%) after FS**
Periodicity	5.23	5.23
Argylal	5.23	-*
H_2CO_3 – minimum	5.23	-*
Carbonate hardness – range	5.23	-*
Carbonate hardness – maximum	5.23	-*
Water depth at runs	5.06	-*
pH – maximum	4.62	-*
Water depth maximum	4.45	-*
PO_4– range	3.92	-*
PO_4 – maximum	3.92	-*
Total phosphorus – range	3.92	3.92
Noncarbonate hardness – maximum	3.05	3.05

*****-not forward selected

Results

In total, 67 taxa were identified, 62 of which were determined to species level (Tab. 2). 1-17 species were recorded per sample and 3-21 species per sampling site. Only *Hydropsyche pellucidula* and *H. incognita* occurred in more than half of the samples. In addition to these two species also *H. contubernalis* and *Psychomyia pusilla* occurred at more than half of the sampling sites. Most species (>90%) were found in less than 10% of samples, and more than 50 % of species in less than 10 % of sampling sites.

The CCA ordination diagram (Fig. 1) indicated that the caddisfly community composition was most strongly associated with periodicity, but also factors that reflect organic pollution and eutrophication (e.g. BOD_5, total phosphorous-range and non-carbonate hardness) were strong determinants of taxa composition (Tab. 2). However, some other environmental variables (e.g. muddy substrate-argylal, H_2CO_3-minimum, carbonate hardness (range and minimum) and water depth at runs) were also strongly correlated with periodicity and might influence caddisfly distribution as well.

Table 2. Inventory of caddisfly taxa recorded during the study of the rivers in the ecoregion “Hungarian Lowland” and codes used in the ordination diagram.

No.	Species	Code	No.	Species	Code
1	*Rhyacophila aurata* Brauer	Rhy_aur	35	*Halesus tesselatus* (Rambur)	Hal_tes
2	*Rhyacophila dorsalis* (Curtis)	Rhy_dor	36	*Ironoquia dubia* (Stephens)	Iro_dub
3	*Rhyacophila fasciata* Hagen	Rhy_fas	37	Limnephilinae gen. sp.1	Limne_sp
4	*Agapetus laniger* (Pictet)	Aga_lan	38	Limnephilinae-juv.	Limne
5	*Allotrichia pallicornis* (Eaton)	Alo_pal	39	*Limnephilus affinis* Curtis	Lim_aff
6	*Orthotrichia* spp.	Ort_spp	40	*Limnephilus binotatus* Curtis	Lim_bin
7	*Hydroptila forcipata* (Eaton)	Hdt_for	41	*Limnephilus lunatus* Curtis	Lim_lun
8	*Hydroptila* spp.	Hdt_lot	42	*Limnephilus rhombicus* (Linnaeus)	Lim_rho
9	*Hydroptila lotensis* (Mosely)	Hdt_spp	43	*Limnephilus stigma* Curtis	Lim_sti
10	*Hydroptila sparsa* Curtis	Hdt_spa	44	*Potamophylax cingulatus* (Stephens)	Pot_cin
11	*Cheumatopsyche lepida* (Pictet)	Che_lep	45	*Potamophylax rotundipennis* (Brauer)	Pot_rot
12	*Hydropsyche angustipennis* (Curtis)	Hyd_ang	46	*Goera pilosa* (Fabricius)	Goe_pil
13	*Hydropsyche bulbifera* McLachlan	Hyd_bul	47	*Silo nigricornis* (Pictet)	Sil_nig
14	*Hydropsyche contubernalis* McLachlan	Hyd_con	48	*Silo pallipes* (Fabricius)	Sil_pal
15	*Hydropsyche dinarica* Marin.-Gospod.	Hyd_din	49	*Silo piceus* (Brauer)	Sil_pic
16	*Hydropsyche incognita* Pitsch	Hyd_inc	50	*Lepidostoma hirtum* (Fabricius)	Lep_hir
17	*Hydropsyche instabilis* (Curtis)	Hyd_ins	51	*Athripsodes albifrons* (Linnaeus)	Ath_alb
17	*Hydropsyche modesta* Navas	Hyd_mod	52	*Athripsodes aterrimus* (Stephens)	Ath_ate
18	*Hydropsyche pellucidula* (Curtis)	Hyd_pel	53	*Athripsodes bilineatus* (Linnaeus)	Ath_bil
19	*Hydropsyche pellucidula/incognita*-juv.	Hyd_p_i	54	*Athripsodes cinereus* (Curtis)	Ath_cin
20	*Hydropsyche saxonica* McLachlan	Hyd_sax	55	*Ceraclea alboguttata* (Hagen)	Cer_alb
21	*Hydropsyche siltalai* Döhler	Hyd_sil	56	*Ceraclea annulicornis* (Stephens)	Cer_ann
22	*Cyrnus trimaculatus* (Curtis)	Cyr_tri	57	*Ceraclea dissimilis* (Stephens)	Cer_dis
23	*Neureclipsis bimaculata* (Linnaeus)	Neu_bim	58	*Ceraclea riparia* (Albarda)	Cer_rip
24	*Polycentropus flavomaculatus* (Pictet)	Pol_fla	59	*Leptocerus interruptus* (Fabricius)	Lpt_int
25	*Lype phaeopa* (Stephens)	Lyp_pha	60	*Mystacides azurea* (Linnaeus)	Mys_azu
26	*Psychomyia klapaleki* Malicky	Psy_kla	61	*Mystacides nigra* (Linnaeus)	Mys_nig
27	*Psychomyia pusilla* (Fabricius)	Psy_pus	62	*Oecetis notata* (Rambur)	Oec_not
28	*Brachycentrus subnubilus* Curtis	Bra_sub	63	*Oecetis testacea* (Curtis)	Oec_tes
29	*Anabolia furcata* Brauer	Ana_fur	64	*Setodes bulgaricus* Kumanski	Set_bul
30	*Chaetopteryx major* McLachlan	Cha_maj	65	*Notidobia ciliaris* (Linnaeus)	Not_cil
31	*Glyphotaelius pellucidus* (Retzius)	Gly_pell	66	*Sericostoma schneideri* Kolenati	Ser_sch
32	*Halesus digitatus* (Schrank)	Hal_dig	67	*Beraeodes minutus* (Linnaeus)	Bde_min
33	*Halesus radiatus* (Curtis)	Hal_rad			

By means of CCA four ecological groups of caddisfly taxa were identified (Fig.1). Group I consists of 7 species: *Ironoquia dubia*, *Limnephilus binotatus*, *L. rhombicus, L. affinis*, *L. lunatus*, *L. stigma* and *Glyphotaellius pellucidus*. These species are projected in the extreme right part of Fig. 1. They were found only in periodical and summer dry rivers. *Neureclipsis bimaculata* and *Hydropsyche angustipennis* represent group II. Both species are mostly related to organically polluted and nutrient-rich rivers and are projected at the top of Fig. 1. Group III consists of species that are projected opposite group II in the diagram. All group III species are related to organically unpolluted and nutrient-poor rivers. Species associated with these rivers are: *Oecetis testacea*, *Athripsodes aterrimus*, *Leptocerus interuptus*, *Ceraclea alboguttata*, *Agapetus laniger*, *Setodes bulgaricus*, *Ceraclea riparia*, *Allotrichia pallicornis*, *Mystacides nigra*, *Oecetis notata* and *Orthotrichia spp*. In the center of the diagram (Fig. 1) many species are summarized in group IV. They occur in rivers which are slightly organically polluted. Some species associated with these rivers are *Rhyacophila fasciata*, *Rhyacophila dorsalis*, *Hydropsyche siltalai*, *H. saxonica*, *H. incognita*, *H. modesta*, *Brachycentrus subnubilus*, *Goera pilosa* and *Psychomyia pusilla*.

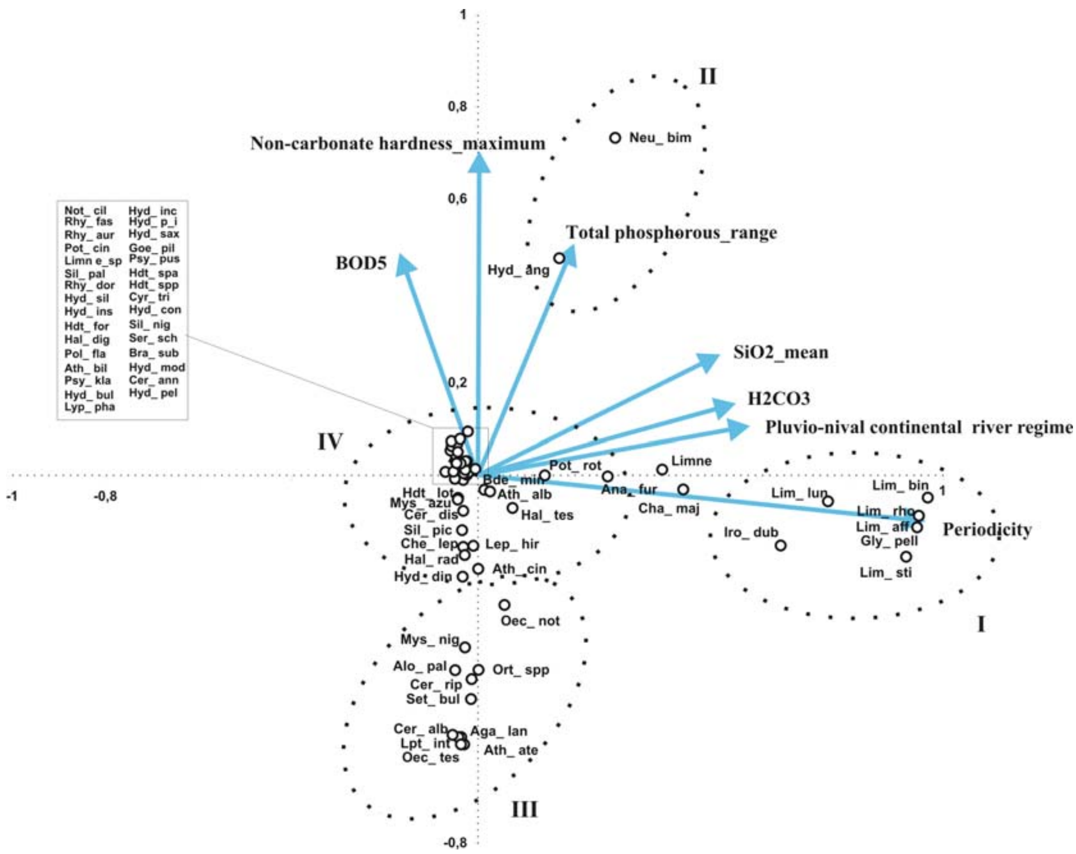

Figure 1. Ordination diagram of the CCA analysis, showing taxa scores (dots) and forward selected (r>0.5) environmental variables (arrows). Ellipses show ecological groups (I-IV) of taxa. See Table 1 for taxa codes. BOD_5 – Biochemical oxygen demand, SiO_2 – Silica, H_2CO_3 – carbonic acid.

Discussion

Caddisfly distribution is, among other factors, often related to stream hydraulics (Higler & Verdonschot 1992), hydrological characteristics (Wiberg-Larsen et al. 2000, Urbanič et al. 2000), temperature (Urbanič 2004) and pollution (Dohet 1999). Differences in the key factors identified are also due to environmental differences within the studied biogeographic areas (Urbanič 2004). In our study only medium and large lowland rivers were studied, and most of them are hydromorphologically altered and slightly or moderately polluted (organically and/or inorganically). That human impact can severely change caddisfly community is also evident in this study, where periodicity influenced caddisfly distribution most. Whereas natural summer dry streams can be found in the Hungarian lowland, the intermittency at the sampling sites in our study was a result of human impact. The distribution of caddisfly taxa along the second axis (Fig. 1) is also a result of human impact, namely water pollution. Compared to the results of previous studies mentioned above, it is obvious that changes in water quality and habitat structure impact caddisfly distribution more than changes of natural variables recognised by other authors. However, the reason could also be that the selected sampling sites represent gradients that are too weak for the selected environmental variables to be more influential in the present study.

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