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Microhabitat preferences of the stone crayfish *Austropotamobius torrentium* (Schrank, 1803)

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ABSTRACT

Key-words: *habitat selection, microhabitat electivity index, Czech Republic*

The stone crayfish *Austropotamobius torrentium* (Schrank, 1803) is a species that usually prefers small and medium-sized streams. It is mainly dependent on coarse grained substrata, which it uses as shelter, but has also been observed on clay in which it creates burrows, similarly to other species of crayfish. In this study, the microhabitat preferences of the stone crayfish in day-time were evaluated. In 2008 (June–November) we collected data on stone crayfish abundances in 1263 patches, recording their position in streams (in five categories: 1. current, 2. lee, 3. shoreline, 4. backwater, 5. rapids), dominant substratum (in seven categories: 1. mud, 2. sand, 3. fine gravel, 4. gravel, 5. pebbles, 6. stones, 7. boulders) in eight streams in the West Bohemia region. This data was evaluated using an index of microhabitat electivity (calculated as the difference between the expected (calculated from all the samples) and actual frequency of occurrence in habitats within a given environmental parameter) and multivariate analysis (redundancy detrended analysis). Substratum type was the major determinant of microhabitat preference for all size classes ($<$ 15 mm, 15–30 mm, 30–60 mm, 60–90 mm, $>$ 90 mm). There was a generalised avoidance of fine-grained substrata and a preference for coarser ones, which was more evident in larger size groups. The substrata character explained 8.7% of the variability in distribution. The parameter "depth" explained 1% of the overall crayfish variability distribution. Nevertheless, an avoidance of greater depths by small stone crayfish individuals was found, as well as an avoidance of shallows by the largest size categories. No major preference was noted for different stream positions (which explained only 0.7% of the microhabitat use variability), but crayfish avoided rapids with higher water velocities.

RÉSUMÉ

Préférences de microhabitat chez l'écrevisse des torrents *Austropotamobius torrentium* (Schrank, 1803)

Mots-clés : *sélection de l'habitat*

L'écrevisse des torrents *Austropotamobius torrentium* (Schrank, 1803) est une espèce qui préfère habituellement les petites et moyennes rivières. Elle est surtout dépendante de substrats caillouteux qu'elle utilise comme abri, mais elle a aussi

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été observée sur argile dans laquelle elle creuse des terriers semblables à ceux d'autres espèces d'écrevisse. Dans cette étude, les préférences de microhabitat pendant le jour de l'écrevisse des torrents ont été évaluées. En 2008 (juin à novembre), nous avons collecté des données d'abondance de l'écrevisse des torrents dans 1263 emplacements, tenant compte de leur position dans la rivière (en cinq catégories : 1. courant, 2. contre-courant, 3. berge, 4. calme, 5. rapide), et du substrat dominant (en sept catégories : 1. vase, 2. sable, 3. graviers fins, 4. graviers, 5. galets, 6. pierres, 7. blocs) dans huit rivières de la région Ouest-Bohème. Ces données ont été analysées en utilisant un index d'électivité de microhabitat (différence entre les fréquences d'occurrence escomptée (calculée pour l'ensemble des échantillons) et observée dans les habitats pour un même paramètre environnemental) et une analyse multivariée (analyse canonique de redondance). Le type de substrat est le déterminant majeur de la préférence du microhabitat pour toutes les classes de taille ($<$ 15 mm, 15–30 mm, 30–60 mm, 60–90 mm, $>$ 90 mm). Il y a un évitement général pour les substrats fins et une préférence pour les plus gros, qui est plus marquée pour les plus grandes tailles. Le type de substrat explique 8,7 % de la variabilité de distribution. Le paramètre « profondeur » explique 1 % de la variabilité totale de distribution. Néanmoins, un évitement des plus grandes profondeurs a été trouvé pour les individus de petite taille, de même qu'un évitement des parties peu profondes par les plus grandes tailles d'écrevisse. Aucune préférence n'a été mise en évidence pour les différentes positions dans la rivière (qui n'expliquent que 0,7 % de variabilité), mais les écrevisses évitent les plus forts rapides.

INTRODUCTION

The stone crayfish *Austropotamobius torrentium* (Schrank) is one of five crayfish species inhabiting the Czech Republic, and is the most threatened of the native species (Kozák *et al.*, 2002). It is currently protected by national law No. 114/1992 as critically endangered, and international conventions also protect this species (Convention of European Wildlife and Natural Habitats, Bern, 1979 and Council Directive 87 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora). The stone crayfish is mentioned in the IUCN Red list as a vulnerable species.

There are fewer data published about the stone crayfish than for other crayfish species in general (*e.g.* Bohl, 1987; Laurent, 1988; Renz and Breithaupt, 2000; Maguire *et al.*, 2002; Streissl and Hödl, 2002) due to its unsuitability for commercial uses (Laurent, 1988). On the other hand, as a result of this commercial disinterest, the distribution of the stone crayfish has not been much affected by human translocation (Troschel *et al.*, 1995; Kappus *et al.*, 1999).

Due to its demands for water quality and morphological characteristics of streams typically inhabited by this species, the stone crayfish seems to be less affected by the crayfish plague caused by *Aphanomyces astaci* which is transmitted by alien crayfish species (Renz and Breithaupt, 2000). However, these requirements and the related Czech distribution of stone crayfish are comparable to those of the noble crayfish *Astacus astacus* (Svobodová *et al.*, 2008). Unfortunately, there have been two recent extinctions caused by crayfish plague in the Czech Republic (Kozubíková *et al.*, 2006).

Many of the ecological requirements of the stone crayfish have already been studied, with focus on water quality (*e.g.* Broquet *et al.*, 2002; Svobodová *et al.*, 2008), riparian vegetation and the overall surroundings of streams (Bohl, 1987), the quality of shelters (Streissl and Hödl, 2002; Pöckl and Streissl, 2005) and overall microhabitat features (*e.g.* Troschel, 1997; Benvenuto *et al.*, 2008; Clavero *et al.*, 2009).

The main aim of this paper is to assess the role of substrata, position and depth in the stream on the occurrence, distribution and abundance of particular of stone crayfish size groups in day-time in typical habitats in the Czech Republic. Such information on the role of different habitat requirements on crayfish populations is essential for effective management and conservation measures for this endangered species (Streissl and Hödl, 2002; Benvenuto *et al.*, 2008).

MATERIAL AND METHODS

> DESCRIPTION OF SAMPLING SITES

Sampling sites were located on eight streams in the Pilsen province, Czech Republic, representing typical streams inhabited by stone crayfish in the country. The streams had predominantly till, stone or partially regulated river basins with different types of substratum. A list of these eight streams with basic data on the source, mouth and sampling sites is given in Table I, and their location in the Czech Republic is depicted in Figure 1.

> CRAYFISH ABUNDANCE AND MICROHABITAT MEASUREMENTS

In total, 13 environmental variables were surveyed in the daytime from June to November 2008. Three plots 270 $\times$ 180 cm in size were randomly chosen in each stream. These plots were divided into 54 (9 $\times$ 6) small patches (size of 30 $\times$ 30 cm). The position in the stream, substratum and depth were estimated for each patch. Stream position was identified as being in one of five categories: 1. current (the part of the river basin with regular flowing water), 2. shoreline (the part of the stream close to river banks with zero or minimum depth), 3. lee (between the shoreline and current), 4. backwaters (parts of the stream where water slows due to some barrier) and 5. rapids (places with high declination or under a barrier, where high current causes ripples). Substratum type was estimated as the dominant substratum in each patch and was identified on a scale (1–7) according to Hauer (2006): 1. mud ($<$ 0.2 mm diameter; *i.e.* materials able to be suspended in the water, including fine organic detritus); 2. sand (0.2–2 mm); 3. fine gravel (2–6 mm); 4. gravel (6–20 mm); 5. pebble (20–50 mm); 6. stone (50–200 mm); 7. boulder ($>$ 200 mm). Depth was measured in the center of each patch and varied between 0–41 cm.

Individual *A. torrentium* were caught by searching through the all possible refugees (*e.g.* turning stones over) by hand and hand netting (Figure 2). The number, size and sex of caught crayfish specimens were measured (total length) by a caliper; the size of individuals which were seen but escaped was estimated.

The 977 measured specimens were divided into five size groups which are based on typical lengths at the end of the 1st, 2nd years and size at maturity: 341 individuals with TL $<$ 15 mm; 192 with 15 $<$ TL $<$ 30; 363 with 30 $<$ TL $<$ 60; 75 with 60 $<$ TL $<$ 90; 6 with TL $>$ 90.

> STATISTICAL ANALYSES

The use of the specific environmental parameters (substratum, stream position and depth) was evaluated by comparing the availability and utilization of each parameter for each size group using χ^2 test at a significance level of 5%. The index of electivity was used to assess the relation between stone crayfish occurrence and the environmental parameter in question. The electivity index was also calculated for each size category. The simple variation of electivity index, used by *e.g.* Copp (1993), Gozlan *et al.* (1998) and Carter *et al.* (2004), was applied: $E = r - p$; where r is the frequency of crayfish using that type of environmental variable (utilization) and p is the frequency (availability) of this type of environmental parameter. Differences between utilization and availability were compared using the Fisher exact (FE) test at a significance level of 5% to discover either a preference or avoidance for the given parameter type. These analyses were evaluated using the NCSS software package.

Microhabitat preferences were also evaluated by means of multivariate analyses, which are appropriate for comparing zoocenoses and environmental parameters due to their stability

Table I
Basic characteristics of the sampling sites.

Tableau I
Caractéristiques principales des sites échantillonnés.

Stream							Sampling site			
		Stream source		Mouth						
Name	Length (km)	Altitude (m a.s.l.)	Town	Altitude (m a.s.l.)	Town	Altitude (m a.s.l.)	Town	GPS	Character
Božkovský brook	5.8	410	Letkov	310	Pilsen	360	Božkov	49°44′16″N 13°27′18″E	Predominantly muddy bottom with stones, frequent changes of water level, drying up in summer
Hůrecký brook	8.5	590	Strašice	395	Svojkovice	450	Hůrky	49°44′40″N 13°41′4″E	Regulated river-basin, bushy riparian vegetation
Rakovský brook	6.4	570	Raková	350	Rokycany	390	Rokycany	49°43′20″N 13°34′44″E	Regulated river-basin, nearby main road
Chejlava – Úzký brook	7.6	490	Těškov	395	Svojkovice	400	Svojkovice	49°45′46″N 13°40′E	Natural character, meanders, riverine forest
Vlčí brook	5.2	470	Kbel	365	Jíno	370	Jíno	49°33′50″N 13°38′2″E	Regulated river-basin shaded by riparian vegetation
Zlatý brook	10.5	515	Skašov	350	Příchovice	440	Horšice	49°31′7″N 13°23′51″E	Natural character, partially shaded by riparian vegetation
Chocenický brook	7.4	490	Jarov	380	Blovice	390	Vlčice	49°34′9″N 13°32′35″E	Regulated river-basin shaded by riparian vegetation
Přešínský brook	5.5	580	Přešín	395	Ždírec	540	Louňová	49°33′49″N 13°37′46″E	Natural character, riverine forest

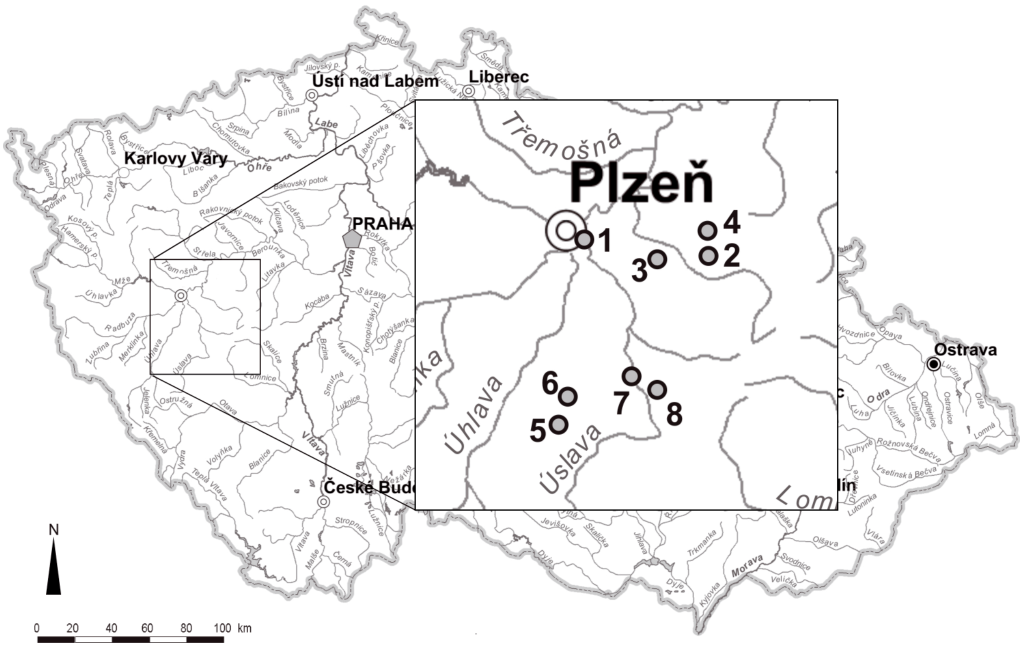

Figure 1

Sampling sites in the study area: 1 – the Božkovský brook, 2 – the Hůrecký brook, 3 – the Rakovský brook, 4 – Chejlava, 5 – the Vlčí brook, 6 – the Zlatý brook, 7 – the Chocenický brook, 8 – the Přešínský brook.

Figure 1

Sites échantillonnés dans la zone d'étude : 1 – ruisseau Božkovský, 2 – ruisseau Hůrecký, 3 – ruisseau Rakovský, 4 – ruisseau Chejlava, 5 – ruisseau Vlčí, 6 – ruisseau Zlatý, 7 – ruisseau Chocenický, 8 – ruisseau Přešínský.

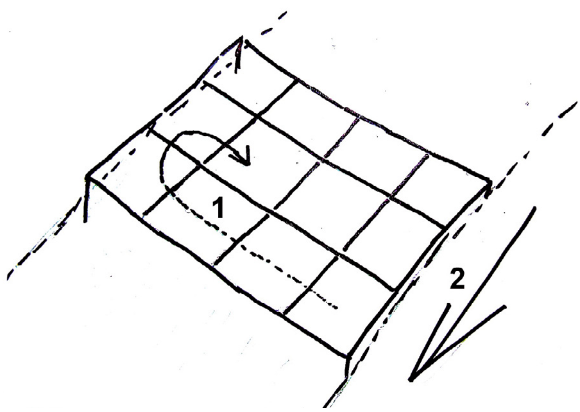

Figure 2

The method of surveying particular patches in each plot (1. direction of surveying the patches, 2. direction of the stream).

Figure 2

Méthode d'échantillonnage des placettes en chaque point (1. direction de suivi des quadrats, 2. direction du courant).

and robustness (Cao *et al.*, 2002). A redundance analysis (RDA) was chosen. The linear model of ordination was used, because the parameter "length of gradients" from preliminary DCA reached a value of 1.5, which is the criterion recommended for the use of linear models instead of the unimodal (CCA) ordination models (ter Braak and Smilauer, 1998).
The variables chosen created a matrix of environmental variables by samples (13 columns × 1263 rows), which was compared with a matrix of abundance (prior to analysis, crayfish abundances were log-transformed) of each size groups by samples (5 columns × 1263 rows). To preserve the influence of a particular stream, the parameter "stream" as a covariate was included in the analysis. The significance of the model thus created was tested using a Monte-Carlo randomization test on both the first axis eigenvalue and the trace (*i.e.* the sum of all canonical eigenvalues) with 499 permutations, the number sufficient for evaluation of the model at a significance level of 0.2% ($P < 0.002$) (Marshal and Elliot, 1998; Magalhaes *et al.*, 2002; Penczak *et al.*, 2004). The pure influence of an individual parameter (*i.e.* substratum type, stream position and depth) was calculated after subtraction of other parameters as covariates. These analyses were carried out in CANOCO 4.5 software and the biplot outputs were displayed using the graphic module CanoDraw.

RESULTS

> *STRUCTURE OF THE STONE CRAYFISH ASSEMBLAGE*

Estimations of abundance were evaluated using data from the particular patches. The total abundance of stone crayfish at sampling sites varied between 3.49 ind·m^{-2} (Božkovský brook) and 13.0 ind·m^{-2} (Vlčí brook). The abundance of the size group "$<$ 15 mm" varied between 1.0 ind·m^{-2} (Božkovský brook) and 16.2 ind·m^{-2} (Hůrecký brook), and this size group formed 21.4–48% of all caught crayfish. The abundance of the size group "15–30 mm" ranged from 0.8 ind·m^{-2} (Božkovský brook) up to 6.8 ind·m^{-2} (Chocenický brook), and created 11.7%–29.4% of the whole population. The size group "30–60 mm" formed 25.2%–47.1% of the total population with abundance varying between 0.8 ind·m^{-2} (Božkovský brook) and 16.5 ind·m^{-2} (Chocenický brook). The size group "60–90 mm" formed 3.2%–12.4% of the population with abundance varying between 0.2 ind·m^{-2} (Božkovský brook) and 3.7 ind·m^{-2} (Chocenický brook). In the size group "$>$ 90 mm" only 6 individuals were caught, but 3 of these individuals were caught in the Chocenický brook plot, creating an abundance there of 0.5 ind·m^{-2}. A summary of these abundance estimations is given in Table II.

> *AVAILABILITY AND UTILIZATION OF ENVIRONMENTAL PARAMETERS*

The substratum of all patches consisted of mud (5.5%), sand (5.1%), fine gravel (2.1%), gravel (16.1%), pebbles (24.5%), stones (37.2%) and boulders (8.6%). The actual utilization of these substratum types by each size group as daytime refuges significantly varied from that expected, *i.e.* utilization corresponding with availability (χ^2, $P < 0.05$). The stream position data were composed of: 27.5% by the type "current", 55.4% by "lee", 11.6% by "shoreline", 4.4% by "backwater" and 0.3% by "rapids". Only the size group "30–60 mm" utilized various stream positions differently from the expected utilization ($\chi^2 = 16.62$, $P = 0.002$). The five depth categories evaluated were composed of: depths from 0–2 cm (20.67%), 2–5 cm (30.8%), 5–10 cm (33.81%), 10–15 cm (10.45%) and $>$ 15 cm (4.3%). Crayfish from the size group "60–90 mm" utilized depth differently than expected from the availability ($\chi^2 = 13.63$, $P = 0.01$) as did crayfish from the size group "$>$ 90 mm" ($\chi^2 = 17.7$, $P = 0.001$). The availability and utilization of each parameter is shown in Figure 3.

> *MICROHABITAT USE*

Specimens of stone crayfish were found in all observed substratum types and in all parts of the stream except for rapids (at any of the depths evaluated, from 1 to 41 cm).

Table II
Structure and density per both size group and site of the eight sampled Austropotamobius torrentium *populations.*

Tableau II
Structure et densité par groupe de taille et par site des huit populations d'*Austropotamobius torrentium* échantillonnées.

Sampling site	Size group															Sampling site		
	< 15 mm			15–30 mm			30–60 mm			60–90 mm			> 90 mm					
	Nr of individuals	Density (ind·m^{-2})	Sex ratio	Nr of individuals	Density (ind·m^{-2})	Sex ratio	Nr of individuals	Density (ind·m^{-2})	Sex ratio	Nr of individuals	Density (ind·m^{-2})	Sex ratio	Nr of individuals	Density (ind·m^{-2})	Sex ratio	Nr of individuals	Density (ind·m^{-2})	Sex ratio
Hůrecký brook	97	16.2	-	40	6.7	0.5	51	8.5	0.6	12	2.0	0.3	2	0.3	1	202	10.4	0.51
Chocenický brook	45	7.5	-	41	6.8	0.6	99	16.5	0.5	22	3.7	0.7	3	0.5	1	210	10.8	0.53
Chejlava	35	5.8	-	14	2.3	0.4	47	7.8	0.5	7	1.2	0.7	0	0.0	-	103	5.3	0.49
Přesinský brook	22	3.7	-	7	1.2	0.7	27	4.5	0.6	4	0.7	0.3	0	0.0	-	60	6.2	0.56
Rakovský brook	24	4.0	-	26	4.3	0.6	38	6.3	0.5	8	1.3	0.6	1	0.2	1	97	5.0	0.53
Vlči brook	86	14.3	-	37	6.2	0.5	61	10.2	0.4	6	1.0	0.6	0	0.0	-	190	13.0	0.45
Zlatý brook	32	5.3	-	27	4.5	0.5	40	6.7	0.7	14	2.3	0.4	0	0.0	-	113	5.8	0.53
Božkovský brook	6	1.0	-	5	0.8	0.4	5	0.8	0.6	1	0.2	1	0	0.0	-	17	3.49	0.60

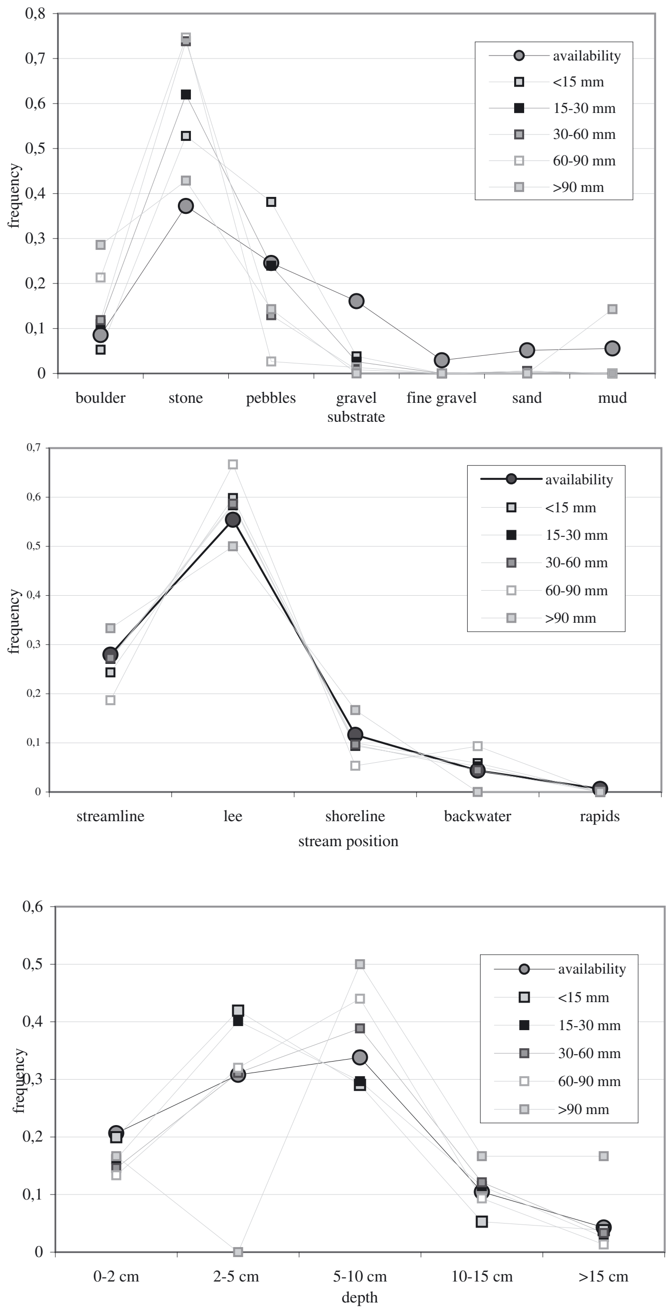

Figure 3
The utilization of each environmental variable in the study area by size groups of the stone crayfish Austropotamobius torrentium*.*

Figure 3
Utilisation de chaque variable environnementale dans la zone d'étude par chaque groupe de taille d'écrevisse des torrents *Austropotamobius torrentium*.

When we consider the index of electivity (see Figure 4), a strong relationship with the rough coarser substrata is noticeable. All size categories show an avoidance of fine-grained substrata and prefer coarser substrata. Larger specimens occurred in parts with coarser substrata *i.e.* stones and boulder while smaller crayfish were found on pebbles and gravel. An overall preference for different stream positions was not demonstrated (FE test, $P > 0.05$). However, the smallest individuals from the size group "0–15 mm" avoided deeper waters,

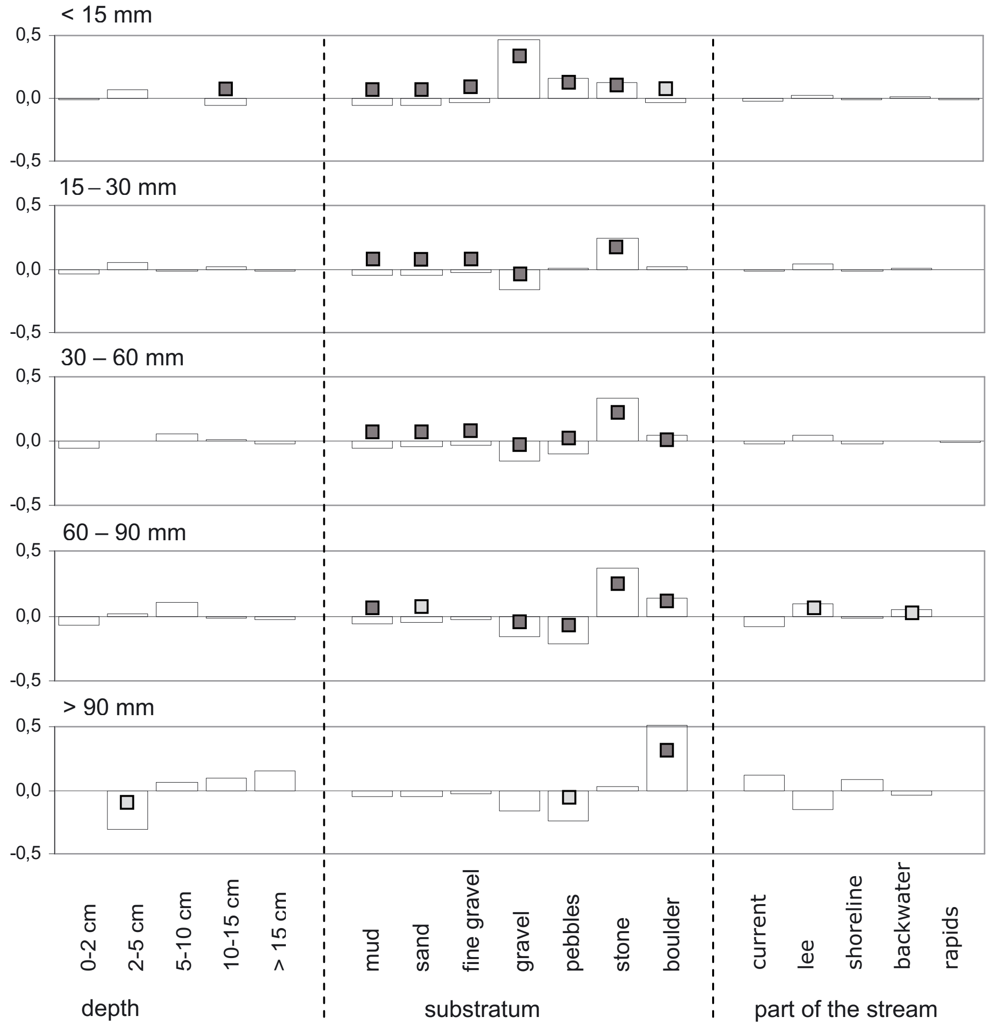

Figure 4
The importance of environmental parameters on the occurrence of stone crayfish size groups using the index of microhabitat electivity (markers – significance of FE test: light grey with $P < 0.08$*, dark grey with* $P < 0.05$*).*

Figure 4
Importance des paramètres environnementaux sur l'occurrence des groupes de taille de l'écrevisse des torrents utilisant l'index d'électivité de microhabitat (marques = niveau du test FE : gris clair $P < 0,08$; gris foncé $P < 0,05$).

whereas the largest nearly always avoided the shallows (FE test, $P = 0.01$, $P = 0.08$ respectively).

The total variability of size-group distribution is well characterized by the model produced (Monte-Carlo test, $F = 12.798$, $P = 0.002$). This model explains 10.2% of the total variability in the distribution of all size categories. The first axis explains 7.6% and is negatively related to crayfish abundance, independent of size. This axis indicates that crayfish are more abundant on sites with more stones and less on fine-grained substrata.

The second axis explains 2.1% of the total variability and is clearly related to crayfish size. Individuals from larger size-groups are associated with boulders and deep areas, whereas smaller crayfish are related to the presence of pebbles.

The pure influence of the parameter "substratum" explains 8.7% of the total variability in distribution of the particular size groups ($F = 19.8$, $P = 0.002$), whereas the parameters "depth"

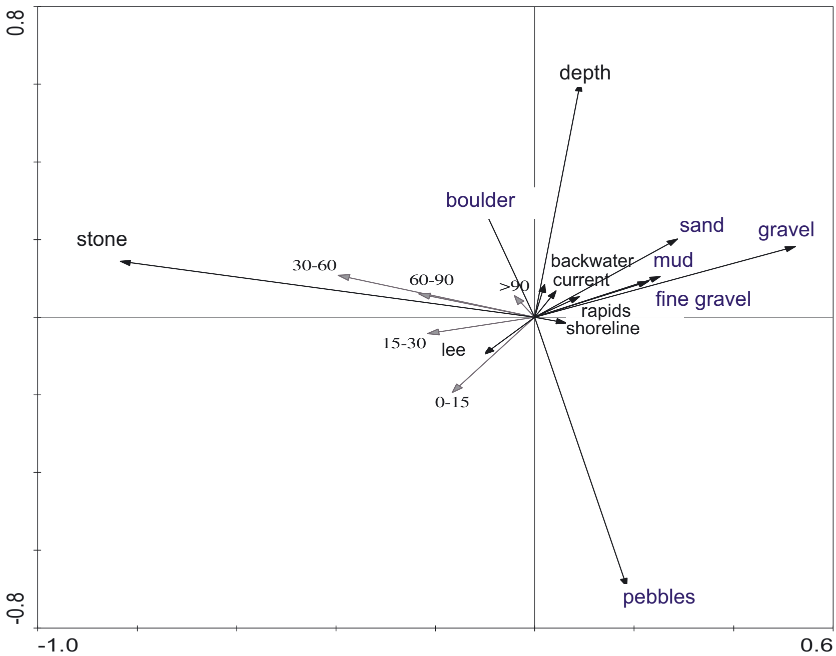

Figure 5
RDA biplot (1st and 2nd axes): environmental variables vs. *abundance of size groups of the stone crayfish* Austropotamobius torrentium*.*

Figure 5
Graphe RDA (1er et 2e axes) : variables environnementales *vs.* abondance des groupes de taille de l'écrevisse des torrents *Austropotamobius torrentium*.

and "stream position" explain only 1% (F = 12.02, P = 0.02) and 0.7% of the variability (F = 2.34, P = 0.01), respectively. These relationships between particular parameters and size groups are presented as a biplot of the 1st and 2nd RDA axes (see Figure 5).

DISCUSSION

The population density of stone crayfish in European streams varies widely. We recorded densities from 3.49 to 13 ind·m^{-2}, similarly as found by Renz and Breithaupt (2000). Fischer *et al.* (2004) found 0.1–4.7 ind·m^{-2} in streams in the Pilsen district. Similarly, Kappus *et al.* (1999) observed populations with densities from 0.04 up to 3.8 ind·m^{-2}.

There is some evidence that *A. torrentium* needs a minimum flow speed in order to colonize a habitat (Renz and Braithaupt, 2000). We evaluated different stream positions with corresponding water flow rates (increasing from "lee" and "backwaters" to "current" and "rapids"), but found no lower limitation on flow. Standing waters were commonly occupied by stone crayfish, as long as pebbles or stones refuges were available. The same results were described by Stloukal and Harváneková (2005) in Slovakian waters. Kutka *et al.* (1996) showed a negative correlation between current velocity and the abundance of *Orconectes propinquus* from Saint Louis (USA). In addition, an upper velocity limit of about 0.20–0.30 m·s^{-1} has been estimated for the stone crayfish (Bohl, 1987; Streissl and Hödl, 2002; Pöckl and Streissl, 2005). Benvenuto *et al.* (2008) noticed an avoidance of waters with current velocity above 0.1 m·s^{-1} by *Austropotamobius pallipes.* Similarly to these papers, no stone crayfish were observed in rapids in this study.

Bohl (1987) reported 0.21 m as the mean depth inhabited by stone crayfish. In this study, most crayfish were found at depths up to 0.15 m, though in deeper water we found crayfish occasionally, similarly as did Renz and Breithaupt (1999). In general, no marked depth preferences were demonstrated, only that the largest specimens avoided shallow waters whereas the smallest avoided deeper parts. These preferences have been described in many previous studies, *e.g.* Kutka *et al.* (1996), Englund and Krupa (2000), Benvenuto *et al.* (2008). On the other hand, Clavero *et al.* (2009) did not find any depth selection by the smallest crayfish. Englund and Krupa (2000) suggested that small crayfish shift their distributions to shallow water to avoid predatory fish, and when these fish are lacking this preference for shallow waters disappears. The distribution of various size groups across a stream can be also affected by the occurrence of terrestrial predators (Fischer *et al.*, 2009).

It is known that crayfish presence is strongly dependent on the structure of the stream bottom (Laurent, 1988; Renz and Breithaupt, 2000). Moreover, habitat diversity influences population density, and higher abundances are expected in streams with greater habitat and bottom variability (Bohl, 1987). In this study, the localities evaluated provided a wide range of bottom structure, and patches were chosen in order to include this variability. We found stone crayfish occupying all substrata types. 85% to 98% of specimens from each particular size group were collected in coarser substrata (the substrata categories boulder, stone and pebbles), similarly as was mentioned by Machino and Füreder (2005), but crayfish were also found in sandy or muddy patches. Some of the streams we studied were predominantly muddy (*i.e.* upper part of the Rakovský brook, the Božkovský brook), and stone crayfish had abundant populations there. The presence of the *A. pallipes* in muddy waters was also reported by Holdich *et al.* (2006), and burrowed stone crayfish have also been observed (Machino and Füreder, 2005).

Still, the occurrence of coarser substrata used as refuges is related to the presence of crayfish (Broquet *et al.*, 2002; Gallagher *et al*., 2005). Refuges afford protection from predation and help crayfish avoid drift (Streissl and Hödl, 2002). We found that larger crayfish use bigger rather than smaller stones as refuges, as was also observed by Streissl and Hödl (2002). This preferred utilization of coarser substrata has also been reported by Stloukal and Harváneková (2005) in Slovakia and by Pöckl and Streissl (2005). The distribution pattern of various size groups can be also be explained by different food requirements and the distribution of food particles along the stream (Englund and Krupa, 2000). Rabeni (1992), Vorburger and Ribi (1999) as well as Benvenuto *et al.* (2008) suggest that bigger specimens are more aggressive and exclude smaller crayfish, but we often observed many specimens of various size groups in the same shelter. This could be explained as an effect of lower aggression levels during the non-active daytime period.

Nevertheless, Renz and Breithaupt (2000) discovered the opposite preference and found smaller individuals under pebbles and stones, and larger adults in sandy substrata. A study based on nighttime observations (Clavero *et al.*, 2009) found a general or partial preference for fine substrata, which shows that microhabitats used during the foraging period may differ significantly from those used in the non-active daytime period.

The presence of refuges for crayfish appears to be a critical parameter, explaining the distribution of groups of individuals along the brook (Broquet *et al*., 2002), as well as the ability of a brook to support a crayfish population (Smith *et al.*, 1996; Füreder *et al.*, 2002). The spreading efficiency of crayfish is usually very limited because they often have a preferred home stone for some period of time (Pöckl and Streissl, 2005). However, if an inappropriate stream is modified to increase the number of shelters it could be consequently colonized by crayfish. This fact should be taken into consideration as a principal factor in crayfish conservation and restocking programs.

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