Knowledge and Management of Aquatic Ecosystems (2009) 394-395, 13 http://www.kmae-journal.org

DOI: 10.1051/kmae/2010005

Recent distribution, population densities and ecological requirements of the stone crayfish (*Austropotamobius torrentium*) in the Czech Republic

P. Vlach[(1)], L. Hulec[(2)], D. Fischer[(3)]

Received September 30, 2009 / Reçu le 30 septembre 2009
Revised December 21, 2009 / Révisé le 21 décembre 2009
Accepted January 5, 2010 / Accepté le 5 janvier 2010

ABSTRACT

Key-words: Austropotamobius torrentium, *stone crayfish, Czech Republic, abundance, distribution, ecology*

The stone crayfish *Austropotamobius torrentium* (Schrank) is one of five species of crayfish inhabiting waters in the Czech Republic, usually occupying small and medium-sized streams. The stone crayfish is protected by national and European laws. At present, stone crayfish are known to occur in 41 streams in the Czech Republic. For each of these streams, we measured the population density, sex ratio and age structure of the stone crayfish populations. The average population density varied between 0.3–4.72 spms·m^{-2}, with a maximum estimated population density at some sites reaching 8.6 spms·m^{-2}. The sex ratio was evaluated only in abundant populations ($>$ 0.5 spms·m^{-2}) and it did not significantly vary from the expected rate of 0.5 (0.3–0.72).

RÉSUMÉ

Distribution actuelle, densité des populations et exigences écologiques de l'écrevisse des torrents (*Austropotamobius torrentium*) en République tchèque

Mots-clés : Austropotamobius torrentium, *écrevisse des torrents, République tchèque, abondance, distribution, écologie*

L'écrevisse des torrents *Austropotamobius torrentium* (Schrank) est une des cinq espèces d'écrevisse présentes dans les eaux de la République tchèque, habituellement dans les petits et moyens cours d'eau. L'écrevisse des torrents est protégée par des lois nationales et européennes. Aujourd'hui, l'écrevisse des torrents est répertoriée dans 41 cours d'eau de la République tchèque. Dans chacun de ces cours d'eau, nous avons estimé la densité de la population, le sexe ratio et la structure en âge des populations d'écrevisse des torrents. La densité moyenne des populations varie entre 0,3 et 4,72 individu·m^{-2}, avec un maximum estimé de densité de population atteignant 8,6 individu·m^{-2} dans quelques sites. Le sexe ratio a été estimé seulement dans les populations abondantes ($>$ 0,5 individu par m^2). Il ne varie pas significativement du sexe ratio de 0,5 (0,3–0,72).

(1) Faculty of Education of the University of West Bohemia, Department of Biology, Klatovská 51, 306 19 Plzeň, Czech Republic, vlach.pavel@mybox.cz
(2) Department of Ecology and Environmental Science, Faculty of Science, Palacký University Olomouc, tř. Svobody 26, 771 46 Olomouc, Czech Republic
(3) Mining Museum Příbram, Nám. Hynka Kličky 293, 261 01 Příbram VI, Czech Republic

Article published by EDP Sciences

INTRODUCTION

The stone crayfish *Austropotamobius torrentium* (Schrank, 1803) is one of five species of crayfish inhabiting waters of the Czech Republic (Kozák *et al.*, 2002). Along with the noble crayfish *Astacus astacus* (L., 1758), it is considered to be an indigenous species, despite the fact that some think its distribution outside the Danube watershed to be the result of past human activities (Machino and Füreder, 2005; Machino and Holdich, 2006), and it is included among critically endangered species under legislation no. 395/1992 Sb. of the law no. 114/1992 Sb. In the Danube drainage area, it occurs down to the "Iron Gate" on the Romanian-Serbian border, and is additionally found in the north-east of Switzerland, Hungary, Romania, Greece (Laurent, 1988), Albania, Slovenia, Bosnia and Hercegovina, Montenegro, Serbia and Ukraine (Machino and Holdich, 2006), Luxembourg (Troschel, 1999), Austria and northern Italy (Füreder and Machino, 1999), Slovakia (Stloukal and Harváneková, 2005), and was also recently discovered in Turkey (Harlioğlu and Güner, 2007). In Germany, it occurs mainly in Bavaria (Bohl, 1987; 1999; Renz and Breithaupt, 1999), Baden-Württemberg (Kappus *et al.*, 1999), as well as in Saxony (Martin *et al.*, 2008). The north-eastern border of its natural range runs through the Czech Republic (Lohniský, 1984b).

The localities inhabited by stone crayfish are often negatively affected by various factors. The primary such factor is the risk from the oomycete parasite *Aphanomyces astaci* Schikora, 1906 (*i.e.*, crayfish plague), which is lethal to indigenous European crayfish (Edgerton *et al.*, 2004). In the past, this disease has caused the extinction of some crayfish populations, and local extinctions still occur at present (Kozák *et al.*, 2002; Kozubíková *et al.*, 2006). Apart from the crayfish plague, the Czech stone crayfish population is endangered by predation from the American mink *Mustela vison* Schreber, 1777 and the European otter *Lutra lutra* (L., 1758) (Fischer *et al.*, 2009). Canalization of streams and other changes to natural river basins as well as intensive fish farming (Fischer *et al.*, 2004a) are also risk factors. Water pollution is also a great problem, despite recent evidence that the stone crayfish has a greater tolerance to certain pollutants than was thought in the past (Svobodová *et al.*, 2008).

This paper provides data about the population density, sex ratio and basic characteristics of streams inhabited by the stone crayfish in the Czech Republic. These data were collected as part of a stone crayfish population monitoring program as part of Appendix No. III of Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora.

MATERIAL AND METHODS

> *DESCRIPTION OF LOCALITIES*

The list of observed streams and their basic characteristics is given in the Table I, and their location in the country is depicted in Figure 1. Monitoring of the stone crayfish populations was carried out at all previously known and new discovered localities in the Czech Republic, *i.e.* 46 streams. Data comes mostly from population monitoring in the years 2007 and 2008, with some additional data from 2009. Monitoring at each stream took place within 2–5 profiles (depending on the length of the stream), each 100 m long. In each of these stream profiles, three patches 10 m^2 in area were randomly chosen, adequately covering the diversity of habitats in the profile. The mean and maximum depth and width were measured, and all potential shelters were examined by hand.

Captured crayfish were kept in containers, sex determined, measured, and separated into five size categories (up to 15 mm, 15–30 mm, 30–60 mm, 60–90 mm, $>$ 90 mm). Total body lengths were measured with a caliper along the median line of the crayfish bodies, from the anterior end of the rostrum to the posterior end of the telson. The population density was calculated as the sum of captured and observed non-captured crayfish per 30 m^2 profile.

For each parameter, the basic descriptive statistics of mean, maximum, minimum, and standard deviation (SD) were calculated. The average sex ratio was calculated as the proportion

Table I

List of the examined localities inhabited by the stone crayfish, Austropotamobius torrentium*, in the Czech Republic (stream name, extent of drainage area, stream length, average flow at the confluence, altitudes of the source and confluence). LTrib, RTrib – left or right tributary, respectively. Streams belonging to the same drainage area are grouped; those from other groups or individual streams are separated by horizontal lines. Arrows indicate a tributary flowing into a larger river. (Don – Danube, Rad – Radbuza, Úhl – Úhlava river, Úsl – Úslava river, Ber – Berounka, Kla – Klabava river, Lit – Litavka river, Vlt – Vltava river, Lab – Elbe, Plo – Ploučnice.)*

Tableau I

Liste des localités prospectées où l'écrevisse des torrents, *Austropotamobius torrentium*, est présente en République tchèque (nom de la rivière, dimension du bassin versant, longueur du cours d'eau, altitude de la source et de la confluence). LTrib, RTrib – affluent de rive gauche ou droite, respectivement. Les cours d'eau d'un même grand bassin versant sont regroupés et séparés par des lignes horizontales. Les flèches indiquent un affluent se jetant dans une rivière plus grande. (Don – Danube, Rad – Radbuza, Úhl – Úhlava river, Úsl – Úslava river, Ber – Berounka, Kla – Klabava river, Lit – Litavka river, Vlt – Vltava river, Lab – Elbe, Plo – Ploučnice.)

id	Stream	Drainage area (km²)	Lenght (km)	Average flow in mouth ($m^3 \cdot s^{-1}$)	Spring altitude (m a.s.l.)	Mouth altitude (m a.s.l.)	Watershed
1	LTrib - Novosedlecký brook		2.6		610	525	Don
2	Medvědí brook		4.96		630	415	Don
3	Radbuza	2179.4	111.5		720	298	Rad
4	↑ Zubřina	213.7	33.1	1.18	552	355	Rad
5	Kbelský brook		6.3		455	365	Úhl
6	Příchovický brook	38.7	10.5	0.1	515	350	Úhl
7	Přešínský brook		5.5		485	395	Úsl
8	Chocenický brook	25.7	7.4	0.11	491	380	Úsl
9	Podhrázský brook	45.1	12.3	0.2	505	371	Úsl
10	Bradava	103.1	20.4	0.59	670	357	Úsl
11	↑ Mítovský brook	32.9	8.6	0.19	672	444	Úsl
12	↑ LTrib - Mítovský brook		4.3		660	560	Úsl
13	↑ Bojovka		6.8		645	435	Úsl
14	↑ Milínovský brook		2.3		435	375	Úsl
15	Kornatický/Mešenský brook	51	16.2	0.24	595	352	Úsl
16	↑ Hrádecký brook		4.2		470	365	Úsl
17	Božkovský brook		4.9		410	305	Úsl
18	↑ RTrib - Božkovský brook		<1		395	355	Úsl
19	Bertínský brook		4.9		409	273	Ber
20	Zbirožský brook	155.7	29	0.6	514	249	Ber
21	Úpoř brook (Míza)	39.5	11.2	0.08	498	246	Ber
22	↑ Hořejší brook		1.9		420	365	Ber
23	Lánský brook		5,1	0.011	429	305	Ber

id	Stream	Drainage area (km²)	Lenght (km)	Average flow in mouth ($m^3 \cdot s^{-1}$)	Spring altitude (m a.s.l.)	Mouth altitude (m a.s.l.)	Watershed
24	Hýskovský brook		4.9		409	219	Ber
25	Všenorský brook		6.4		406	207	Ber
26	Radotínský brook	68.5	22.8	0.12	405	194	Ber
27	Padrt'ský brook (Klabava)	372.3	49	2.1	678	286	Kla
28	↑ Skořický brook		9.8		663	407	Kla
29	↑ RTrib - Skořický brook		2.5		573	463	Kla
30	↑ Příkosický brook		3.5		500	435	Kla
31	↑ Tisý brook		5.6		703	488	Kla
32	↑ Holoubkovský brook	83.1	23.4	0.43	605	356	Kla
33	↑ Hůrecký brook		6.7		573	393	Kla
34	↑ Chejlava (Úzký brook)		6.4		489	396	Kla
35	↑ Rakovský brook		5.3		451	352	Kla
36	Stroupinský brook	109.9	22.1	0.38	573	264	Lit
37	↑ Bzovský brook		3.1		423	310	Lit
38	↑ Kublovský brook	25.9	7.1	0.05	458	291	Lit
39	Zákolanský brook	265.6	28.2	0.63	418	168	Vlt
40	Luční brook (the Giant Mts.)		9,6		398	398	Lab
41	↑ Javornický brook		4.2		685	410	Lab
42	↑ Bolkovský brook		2.2		465	395	Lab
43	Luční brook (Bohemian Highlands)	38.7	8.3	0.54	497	370	Lab
44	↑ Trojhorský brook and trib.	6.4			415	232	Lab
45	Hunikovský brook				335	282	Plo
46	Valdecký brook		5,4	440	340	340	Plo

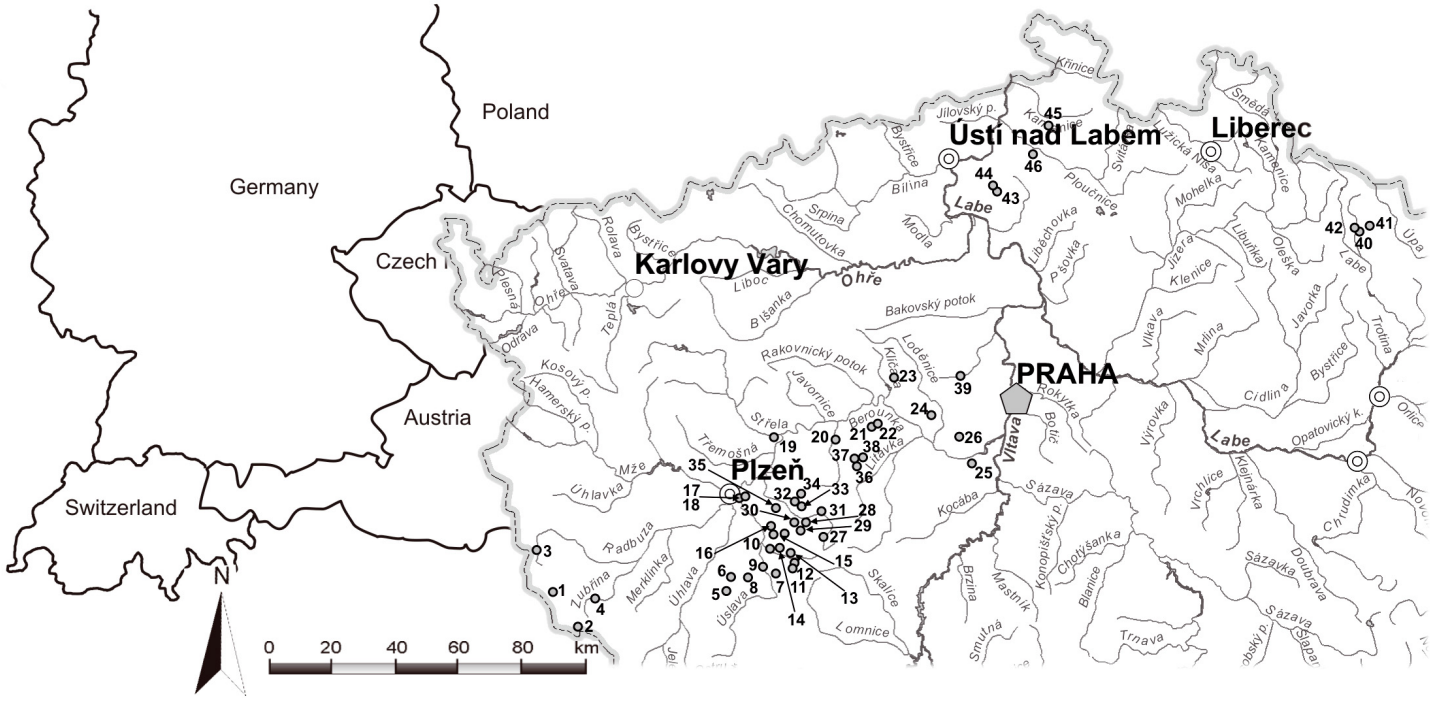

Figure 1

Observed localities with a recorded occurrence of the stone crayfish Austropotamobius torrentium *in the Czech Republic (from CENIA).*
1. Left tributary of the Novosedlecký brook, 2. Medvědí brook, 3. Radbuza, 4. Zubřina, 5. Kbelský brook, 6. Příchovický brook, 7. Přešínský brook, 8. Chocenický brook, 9. Podhrázský brook, 10. Bradava, 11. Mítovský brook, 12. left tributary of the Mítovský brook, 13. Bojovka, 14. Milínovský brook, 15. Kornatický/Mešenský brook, 16. Hrádecký brook, 17. Božkovský brook, 18. right tributary of the Božkovský brook, 19. Bertínský brook, 20. Zbirožský brook, 21. Míza (Úpoř), 22. Hořejší brook, 23. Lánský brook, 24. Hýskovský brook, 25. Všenorský brook, 26. Radotínský brook, 27. Padr'ský brook (Klabava), 28. Skořický brook, 29. right tributary of the Skořický brook, 30. Příkosický brook, 31. Tisý brook, 32. Holoubkovský brook, 33. Hůrecký brook, 34. Chejlava (Úzký brook), 35. Rakovský brook, 36. Stroupinský brook, 37. Bzovský brook, 38. Kublovský brook, 39. Zákolanský brook, 40. Luční brook (the Giant Mts.), 41. Javornický brook, 42. Bolkovský brook, 43. Luční brook (Bohemian Highlands), 44. Trojhorský brook and its tributary, 45. Huníkovský brook, 46. Valdecký brook.

Figure 1
Sites étudiés où l'écrevisse des torrents *Austropotamobius torrentium* est présente en République tchèque.

of numbers of males to all specimens. These observed sex ratios were compared with expected values using the χ^2 test.

Basic geographic parameters of each monitored stream were taken from a map: length of the stream, and altitudes of the source and confluence. In some cases, data on drainage area and average flow at the confluence were taken from a previously published report (Vlček *et al.*, 1984).

RESULTS

In this study, occurrence of the stone crayfish was confirmed at 39 of the 44 monitored streams in the years 2007–2008. In 2009, we examined the crayfish population in two additional streams where this species had been newly reported (a tributary of the Novosedlecký brook in the Český les Mts. (Cehlárikóvá, *in verb*.) and the Valdecký brook (Franěk, *in verb.*)). The average stream length where the stone crayfish was present was 13.3 km (1.9–112 km, SD = 18.7). The average flow at the confluence of 20 localities, mainly larger streams (Vlček *et al.*, 1984), was 0.445 $m^3 \cdot s^{-1}$ (SD = 0.51, median of 0.24 $m^3 \cdot s^{-1}$). The width of the streams varied between 0.7–7.5 m (average 2.65 m, SD = 1.47), and crayfish were found at depths from 0.01–0.70 m.

Streams inhabited by the stone crayfish had source altitudes ranging between 335 m a.s.l. and 720 m. a.s.l. The highest-elevation site where stone crayfish occurred was 640 m a.s.l. at the Bílý brook in the Brdy Mts. (the source of the Bradava river), followed by other sites in the Brdy Mts. at around 600 m a.s.l. and the newly reported tributary of the Novosedlecký stream in the Český les Mts. at the same altitude. The lowest-elevation site recorded was 235 m a.s.l. at the Zákolanský brook. The majority of streams occupied by the stone crayfish had confluence altitudes between 290–395 m a.s.l., and the lowest was at 168 m a.s.l.

At nine observed streams, the stone crayfish *A. torrentium* was sympatric with the noble crayfish *A. astacus* (Zubřina, Chocenický brook, Mítovský brook, Bradava river, Příkosický brook, Bzovský brook, Stroupinský brook and Zákolanský brook); at the Padrt'ský brook the stone crayfish was sympatric with both the noble and the narrow-clawed crayfish *Astacus leptodactylus*.

The average density of stone crayfish in the Czech Republic was 1.42 spms$\cdot m^{-2}$ (0.3–4.72 spms$\cdot m^{-2}$, SD = 1.19). It is noteworthy that maximum values found for the 30 m^2 profiles varied between 0.1–8.4 spms$\cdot m^{-2}$, while at some smaller patches of about 10 m^2 they were above 8.6 spms$\cdot m^{-2}$.

The average sex ratio for all streams was 0.48 (ranging from 0.31–0.72) and did not significantly differ from the expected sex ratio of 0.5 ($\chi^2 = 3.36$, $p = 0.96$). The values of abundance and sex ratio are given in Table II.

The largest captured crayfish measured 105 mm (male), and 94 mm (female). Both individuals were captured in the Luční brook below the Giant Mts.

DISCUSSION

At present, stone crayfish are reported to occur in 46 streams in the Czech Republic, though we were unable to confirm its presence at five of these streams. Historically, occurrence of the stone crayfish *A. torrentium* has been mentioned in the Czech literature many times (*e.g.* Pecina, 1979; Moucha, 1981; Lenský, 1982; Lohniský, 1984a), but many of these records may be distorted by possible species confusion. Lohniský (1984b) carried out the first relevant revision of these data, and reported a list of verified occurrences at eight streams (the Luční, Křečovický, Týnecký, Radotínský, Klíčava, Ryšava, Úpořský and Řevnice brooks). Some later data about the possible presence of the stone crayfish remained unverified (Houda and Tichý, 1987; Pešout *et al.*, 1996). Kozák *et al.* (2002) examined the existence of the stone crayfish at the Zubřina stream in Domažlicko, which had been previously mentioned by Ďuriš and

Table II

Number of profiles, mean and maximum population density (spms·m^{-2}), average sex ratio of the stone crayfish, Austropotamobius torrentium*, and the occurrence of other crayfish species (Aa –* Astacus astacus*, Al –* Astacus leptodactylus*) in the examined streams in the Czech Republic. Streams are grouped by horizontal lines according to drainage area. Arrows indicate a tributary flowing into a larger river. Grey color indicates streams without the presence of stone crayfish in 2007–2009.*

Tableau II

Nombre de profils, moyenne et maximum de densité de population (individu·m^{-2}), sexe ratio moyen de l'écrevisse des torrents, *Austropotamobius torrentium*, et occurrence d'autres espèces d'écrevisse (Aa – *Astacus astacus*, Al – *Astacus leptodactylus*) dans les eaux prospectées de la République tchèque. Les cours d'eau d'un même grand bassin versant sont regroupés et séparés par des lignes horizontales. Les flèches indiquent un affluent se jetant dans une rivière plus grande. Le grisé indique les cours d'eau où l'écrevisse des torrents était absente en 2007–2009.

id	Stream	Year	Nr profiles	Mean abundance (spms·m^{-2})	Max abundance (spms·m^{-2})	Sex ratio	Other crayfish
1	LTrib - Novosedlecký brook	2009	2	1.8	2.2	0.385	
2	Medvědí brook	2009	2	0.86	0.97	0.41	
3	Radbuza	2008	2	0.18	0.23		
4	↳ Zubřina	2008	2	0.3	0.46	0.4	Aa
5	Kbelský brook	2007	3	2.76	2.63	0.465	
6	Příchovický brook	2008	3	2.162	2.96	0.535	
7	Přešínský brook	2007	2	3.8	3.015	0.39	
8	Chocenický brook	2008	2	2.12	3.16	0.655	Aa
9	Podhrázský brook	2008	3	0.46	1.83	0.65	
10	Bradava	2008	5	1.26	3.1	0.51	Aa
11	↳ Mítovský brook	2008	3	2.044	2.477	0.593	Aa
12	↳ LTrib - Mítovský brook	2008	2	2.25	2.87	0.4525	
13	↳ Bojovka	2008	2	1.3	1.6	0.561	
14	↳ Milínovský brook	2008	2	0.1	0.1	0.375	
15	Kornatický/Mešenský brook	2007	4	1.1	1.3	0.575	
16	↳ Hrádecký brook	2008	2	4.7225	6.06	0.475	
17	Božkovský brook	2007	1	0.215	0.36	0.4	
18	↳ RTrib - Božkovský brook	2007	1	0.3	0.4	0.625	
19	Bertínský brook	2007	2	2.89	3.86	0.51	
20	Zbirožský brook	2008	2	0.00	0.00		
21	Úpoř brook (Míza)	2007	4	4.70	8.40	0.42	
22	↳ Hořejší brook	2007	1	0.40	0.30		
23	Lánský brook	2007	2	0.00	0.00		
24	Hýskovský brook	2007	2	0.00	0.00	-	
25	Všenorský brook	2007	3	1.66	2.23	0.54	
26	Radotínský brook	2008	2	1.17	2.00	0.32	
27	Padrský brook (Klabava)	2007	3	1.37	2.17	0.31	Aa, Al
28	↳ Skořický brook	2007	2	1.23	2.33	0.65	
29	↳ RTrib - Skořický brook	2007	2	1.97	2.57	0.56	
30	↳ Příkosický brook	2007	2	1.60	1.73	0.72	Aa
31	↳ Tisý brook	2008	2	2.23	0.40	0.45	
32	↳ Holoubkovský brook	2008	2	0.00	0.00		
33	↳ Hůrecký brook	2007	2	3.30	2.13	0.41	
34	↳ Chejlava (Úzký brook)	2007	2	2.96	1.43	0.45	
35	↳ Rakovský brook	2007	2	2.07	2.83	0.39	
36	Stroupinský brook	2008	3	2.16	3.93	0.42	Aa
37	↳ Bzovský brook	2007	2	1.88	3.77	0.45	Aa
38	↳ Kublovský brook	2007	2	1.02	2.03	0.35	
39	Zákolanský brook	2007	2	2.12	3.97	0.48	Aa
40	Luční brook (the Giant Mts.)	2008	2	1.09	1.53	0.53	
41	↳ Javornický brook	2008	2	0.00	0.00		
42	↳ Bolkovský brook	2008	1	0.20	0.20	0.54	
43	Luční brook (Bohemian Highlands)	2007	2	0.88	2.06	0.32	
44	↳ Trojhorský brook and trib.	2007	2	0.20	0.30	0.55	
45	Huníkovský brook	2007	2	2.19	4.60	0.54	
46	Valdecký brook	2009	0	-	-	-	

Holzer (1988). Occurrence of the stone crayfish was also subsequently found in the Padrt'ský stream at an army base in the Brdy Mts. (Fischer, 2000). Kozák *et al.* (2002) carried out a revision of known data, and the presence of stone crayfish was verified at four localities (the Luční, Úpořský, Padrt'ský (Klabava), and Zubřina brooks). In the following years the stone crayfish was noted at 16 other localities of the Úslava and Úhlava watersheds in the Brdy Mts. area (Fischer and Fischerová, 2003; Fischer *et al.*, 2004a, 2004b). Other localities were discovered while mapping the occurrence of crayfish in the Czech Republic during the years 2003–2005 (Chobot, 2006).

In result, the occurrence of the stone crayfish in the Czech Republic has been demonstrated at 41 localities. In the last decade, the number of known localities has increased more than tenfold, and recent new discoveries indicate that this number will probably continue to grow.

This number of localities inhabited by the stone crayfish is relatively small compared to adjacent countries; nevertheless, the presence of the stone crayfish in the Czech Republic is likely very important for knowledge about the distribution of this crayfish species. Considering the distribution at the beginning of the 21st century, Machino and Holdich (2006) came to the opinion that the stone crayfish is only indigenous in the Danube watershed, being stocked by humans in other parts of Europe. The isolated and patchy distribution in the Czech Republic known at that time (Kozák *et al*., 2002) supported this theory. However, the numerous records of isolated, but often abundant populations of the stone crayfish from the Labe watershed, supported by records from Saxony, indicate the probability of relict populations.

In the Czech Republic there are also two populations of the stone crayfish which belong to the Danube watershed, as well as populations which create the northern distribution border of this species.

The stone crayfish lives primarily in small streams with river beds having natural character (*e.g.* meanders, large depth variability) (Pöckl, 1999). It occurs in streams with various substrata types (Pöckl, 1999; Renz and Breithaupt, 2000), though it prefers coarser bottom material (Streissl and Hödl, 2002b). In the Czech Republic, it has been found mainly in areas with sand, gravel, pebbles or stone bottoms, but it can even be found in strictly regulated stone-lined corridors (the Bradava, Mítovský, and Příchovický (Zlatý) brooks), or in clay bottoms in which it builds burrows (the Chocenický, Zákolanský, and Rakovský brooks).

The elevation range of the stone crayfish reported in the literature is varied. Kappus *et al.* (1999) and Vogt *et al.* (1999) found stone crayfish at 180–549 m a.s.l. in Baden-Würtenberg, Bohl (1987) at 310–820 m a.s.l. in Bavaria, and Renz and Breithaupt (2000) at 400–500 m a.s.l. in southern Germany. It is worth mentioning the existence of stone crayfish at 510–810 m a.s.l. in Slovenia (Machino, 1997) and probably the highest-elevation population in northern Tyrol, Austria, at 838–1124 m a.s.l. (Füreder and Machino, 1999). In the Czech Republic, stone crayfish have been reported to live from 335 m a.s.l. in the Křivoklát region to 425 m a.s.l. in foothills of the Giant Mts. (Ďuriš *et al.*, 2001). In western Bohemia, the stone crayfish was found at altitudes ranging from 360–630 m a.s.l. (Fischer *et al.*, 2004a). We found the existence of stone crayfish in lower-elevation streams (*e.g.*, the Zákolanský stream with crayfish occurring between 235–265 m a.s.l., the Radotínský stream on the south western edge of Prague at cca 240 m a.s.l., and the Hýskovský stream also at 240 m a.s.l.). The optimum altitude for the species, according to Bohl (1987), is around 425 m a.s.l.

Stone crayfish live in streams with dynamically changing flow. The maximum flow rates found by Bohl (1987) were from 0.2–0.3 $m \cdot s^{-1}$, Renz and Breithaupt (1999) found crayfish in streams with flow rates from 0.01 to 0.62 $m \cdot s^{-1}$, and 0.15–0.56 $m \cdot s^{-1}$ (Renz and Breithaupt, 2000). This coincides with our measured values from 0.1–0.3 $m \cdot s^{-1}$. Kappus *et al.* (1999) reported average flow rates of 0.005–0.015 $m^3 \cdot s^{-1}$ for stone crayfish localities in Germany (Baden-Würtenberg), and no stone crayfish were found in waters with flow below 0.002 $m^3 \cdot s^{-1}$ or above 0.05 $m^3 \cdot s^{-1}$. This is in contrast with the data from our waters, where *A. torrentium* often lives in lower-elevation sections of intermediately sized streams with flow above 0.5 $m^3 \cdot s^{-1}$.

In this study, stone crayfish were found in streams with widths from 0.7–7.5 m. Ďuriš *et al.* (2001) reported widths ranging from 0.3 to 2.5 m at Zubřina, 2–4 m at the Luční stream below the Giant Mts., and 0.5–2.5 at the Míza in the Křivoklát region. Fischer *et al.* (2004b) recorded

the existence of stone crayfish in central and western Bohemia in streams with width of 0.4 m to small rivers up to 8 m wide. Bohl (1987) stated an average width of streams inhabited by *A. torrentium* of 1.47 m in Bavaria, while Kappus *et al.* (1999) reported 1–2 m with a maximum width of 0.5–50 m, Streissl and Hödl (2002b) 1.6–5.2, and Renz and Breithaupt (1999) from 0.8 to 2 m in Baden-Würtenberg.

We found stone crayfish in waters with practically zero depth, but also in pools about 0.7 m deep. This corresponds with data by Ďuriš *et al.* (2001). Renz and Breithaupt (1999) recorded occurrences of stone crayfish at depths of 0.04–0.15 m, but also in depths down to 3 m. Bohl (1987) stated an average depth of 0.21 m. for waters with stone crayfish. Analysing the distance of crayfish localities from stream sources, Bohl (1987) reported an average of 2.1 km from the source for stone crayfish populations, compared to an average distance of 15.1 km for the noble crayfish. This author also mentioned an exception, where *A. torrentium* was found downstream of a noble crayfish site. The sympatric existence of both species in the Zubřina stream in Domažlicko is analogous. The noble crayfish is found there in the upper part of the section inhabited by the stone crayfish; the centre of its population is in lower sections, however, in tributaries and ponds with lower water quality. The situation is similar at the Padrt'ský brook (Fischer, 2000).

The average flow at the confluence reported for 20 localities (Vlček *et al.*, 1984), mainly larger streams, was 0.445 $m^3 \cdot s^{-1}$ (SD = 0.51) with a median of 0.24 $m^3 \cdot s^{-1}$. These values would certainly be lower if all streams were included in the calculation. Stone crayfish occurred in streams which sometimes dry out, with a flow rates of less than 0.01 $m^3 \cdot s^{-1}$, and even in streams with average flow in excess of 0.5 $m^3 \cdot s^{-1}$ at the confluence.

Streams inhabited by *A. torrentium* are shaded at a level of 59% by vegetation (Bohl, 1987), primarily by woodlands. The terrestrial surroundings of stone crayfish localities were analyzed by Bohl (1987) and sequenced in order of preference: (1) coniferous woods, (2) deciduous woods, (3) pastures, (4) mossy growth, (5) grassland, (6) settlements, (7) farming. Our observed streams coincide with these described environments, including sections of streams flowing through larger towns (Bradava in Spálené Poříčí and Nezvěstice, the Luční stream in Rudník), or deforested environments used for farming (the Padrt'ský and Příkosický brooks).

The population densities of stone crayfish differ markedly among individual streams. Kappus *et al.* (1999) recorded abundances from 0.04 to 3.8 crayfish per m^2. We discovered population densities between 0.3–4.7 spms$\cdot m^{-2}$, which agrees with the data from Fischer *et al.* (2004a). In some areas however, it exceeded 8 spms$\cdot m^{-2}$ and even 12 spms$\cdot m^{-2}$ in particular stony sections (Hulec, *in verb*.), which corresponds with data from Renz and Breithaupt (2000). These data are likely significantly underestimations, since when catching crayfish from emptied river sections, densities often exceed extreme abundances of 20 spms$\cdot m^{-2}$ (Fischer, *in verb*.).

The largest captured individuals were a male of 105 mm in the total body length and a female of 94 mm, which corresponds with the usual maximum sizes of this species (*e.g.* Maguire *et al.*, 2002; Streissl and Hödl, 2002a). These specimens were captured in the Luční brook below the Giants Mts., and no specimens from other Czech localities exceeded 100 mm.

Most of the populations of the stone crayfish in the Czech Republic have good population characteristics, but in general, all the populations are endangered and influenced by many negative factors. Dense populations are often affected by predation from the American mink *Mustela vison* and European otter *Lutra lutra.* Evidence of the predation of crayfish by these species was seen at 19 streams, although it likely occurs at all localities (Fischer *et al.*, 2009).

Another negative factor is the endangerment associated with the manipulation of crayfish, particularly by fishermen in managed streams or where other crayfish species are in close vicinity. The risk of contamination by the fungal "crayfish plague" infection caused by *Aphanomyces astaci* is very high. This infection is spread in the Czech Republic by non-indigenous American crayfish species, especially the spiny-cheek crayfish *Orconectes limosus* (Rafinesque, 1817) and the less widespread signal crayfish *Pacifastacus leniusculus* (Dana, 1852). The recent distribution of the spiny-cheek crayfish has been described by Petrusek *et al.* (2006). Crayfish plague is an ongoing problem in the country, as shown

by a massive death of crayfish with plague symptoms in the years 2004–2005 (Kozubíková *et al.*, 2006). Unfortunately, the populations at two of the localities monitored in this paper (the lower part of the Úpoř brook and Hýskovský brook) were recently decimated by crayfish plague (Kozubíková *et al.*, 2006).

ACKNOWLEDGEMENTS

We would like to thank the data collectors (P. Cehlárikóvá from the administration of the Landscape Protected Area Český les, A. Hoffmanová from the administration of the Landscape Protected Area Křivoklátsko and V. Říš from the Agency For Nature Conservation And Landscape Protection Plzeň).
This study was supported by a project of the Czech Ministry of Environment (VaV/620/01/03) and project no. 062 “History of the Czech-Bavarian border region in 1945–2008” program cross border participation Aim 3 The Czech Republic – Independent state of Bavaria 2007–2013.

REFERENCES

Bohl E., 1987. Comparative studies on crayfish brooks in Bavaria (*Astacus astacus* L., *Austropotamobius torrentium* Schr.). *Freshwater Crayfish*, *7*, 287–294.

Bohl E., 1999. Crayfish stock situation in Bavaria (Germany) – attributes, threats and chances. *Freshwater Crayfish*, *12*, 765–777.

Chobot K., 2006. Mapping of crayfish. *Ochrana přírody*, *61*, 2, 57–59 [in Czech].

Ďuriš Z. and Holzer M., 1988. Les écrevisses en Tchécoslovaquie. *L’astaciculteur de France*, *16*, 1–4.

Ďuriš Z., Kozák P., Policar T. and Theimer J., 2001. The stone crayfish *Austropotamobius torrentium* (Schrank) in the Czech Republic. *Čas. Slez. Muz. Opava (A)*, *50 (suppl.)*, 85–93 [in Czech with English abstract].

Edgerton B.F., Henttonen P., Jussila J., Mannonen A., Paasonen P., Taugbøl T., Edsman L. and Souty-Grosset C., 2004. Understanding the causes of disease in European freshwater crayfish. *Conserv. Biol.*, *18*, 6, 1466–1474.

Fischer D., 2000. Final report of occurrence of stone crayfish form the Příbram district, unpublished data, dep. AOPK ČR Praha, 31 p. [in Czech].

Fischer D. and Fischerová J., 2003. List of recorded occurrences in the Úslava, Úhlava and Radbuza watershed, unpublished data, dep. AOPK ČR Praha, 15 p. [in Czech].

Fischer D., Bádr V., Vlach P. and Fischerová J., 2004a. New knowledge about distribution of the stone crayfish in the Czech Republic. *Živa*, *52*, 79–81 [in Czech].

Fischer D., Fischerová J., Vlach P., Bádr V. and Štambergová M., 2004b. Knowledge about distribution of the stone crayfish in the Czech Republic, basic ecological parameters of its populations and methods of its collection. *In*: Bryja J. and Zukal J. (eds.), Zoologické dny Brno 2004, 46 [in Czech].

Fischer D., Pavluvčík P., Sedláček F. and Šálek M., 2009. Predation of the alien American mink, *Mustela vison* on native crayfish in middle-sized streams in central and western Bohemia. *Folia Zool.*, *58*, 1, 45–56.

Füreder L. and Machino Y., 1999. Past and present crayfish situations in Tyrol (Austria and Northern Italy). *Freshwater Crayfish*, *12*, 751–764.

Harlioğlu M.M. and Güner U., 2007. A new record of recently discovered crayfish, *Austropotamobius torrentium* (Schrank, 1803), in Turkey. *Bull. Fr. Pêche Piscic.*, 387, 1–5.

Houda J. and Tichý H., 1987. About crayfish and their occurrence around the Louny region. *Almanach*, Okr. knihovna v Lounech, 30 p. [in Czech].

Kappus B., Peissner T. and Raver-Jost C., 1999. Distribution and habitat conditions of crayfish populations in the urban freshwater systems of Stuttgart (Baden-Württenberg, Germany). *Freshwater Crayfish*, *12*, 778–785.

Kozák P., Ďuriš Z. and Policar T., 2002. The stone crayfish *Austropotamobius torrentium* (Schrank) in the Czech Republic. *Bull. Fr. Pêche Piscic.*, 367, 707–713.

Kozubíková E., Petrusek A., Ďuriš Z., Kozák P., Geiger S., Hoffmann R. and Oidtmann B., 2006. The crayfish plague in the Czech Republic – review of recent suspect cases and a pilot detection study. *Bull. Fr. Pêche Piscic.*, 380-381, 1313–1323.

Laurent P.J., 1988. *Austropotamobius pallipes* and *A. torrentium*, with observations on their interaction with other species in Europe. *In*: Holdich D.M. and Lowery R.S. (eds.), Freshwater Crayfish: Biology, Management and Exploitation, Chapman and Hall, London, 341–364.

Lenský V., 1982. Rak kamenáč / Stone crayfish. *Naší přírodou*, *2*, 11, 6–7 [in Czech].

Lohniský K., 1984a. Notes to the present occurrence of stone crayfish in the Czech Republic. *Časopis Národního muzea*, 195–201 [in Czech].

Lohniský K., 1984b. Occurrence of crayfish in East Bohemia and the changes in last decades. *Zpravodaj*, Krajské museum [in Czech].

Machino Y., 1997. Crayfish of the upper Soca and upper Sava rivers, Slovenia. *Bull. Fr. Pêche Piscic.*, 374, 721–729.

Machino Y. and Füreder L., 2005. How to find a stone crayfish *Austropotamobius torrentium* (Schrank, 1803): A biogeographic study in Europe. *Bull. Fr. Pêche Piscic.*, 376-377, 507–717.

Machino Y. and Holdich D.M., 2006. Distribution of Crayfish in Europe and Adjacent Countries: Updates and Comments. *Freshwater Crayfish*, *15*, 292–323.

Maguire I., Erben R., Klobučar G.I.V. and Lajtner J., 2002. Year cycle of *Austropotamobius torrentium* (Schrank) in streams on Medvednica Mountain (Croatia). *Bull. Fr. Pêche Piscic.*, 367, 943–957.

Martin P., Pfeifer M. and Füllner G., 2008. First record of the stone crayfish *Austropotamobius torrentium* (Schrank, 1803) (*Crustacea*: *Decapoda*: *Astacidae*) from Saxony (Germany). *Faunistische Abhandlungen*, *26*, 103–108.

Moucha P., 1981. Stone Crayfish in the Landscape Protected Area Křivoklátsko. *Naší přírodou*, *1*, 1, 13 p. [in Czech].

Pecina P., 1979. Stone crayfish. *In*: Pecina P. and Čepická A. (eds.), Kapesní atlas chráněných a ohrožených živočichů, 1st part, Prag, SPN, 219 p. [in Czech].

Pešout P., Švarc B. and Kříž K., 1996. Occurrence of brook lamprey (*Lampetra planeri*) in the Novohradské Mountains. *Bulletin Lampetra, II*, 65–67.

Petrusek A., Filipová L., Ďuriš Z., Horká I., Kozák P., Policar T., Štambergová M. and Kučera Z., 2006. Distribution of the invasive spiny-cheek crayfish (*Orconectes limosus*) in the Czech Republic. Past and present. *Bull. Fr. Pêche Piscic.*, 380-381, 903–917.

Pöckl M., 1999. Distribution of crayfish species in Austria with special reference to introduced species. *Freshwater Crayfish*, *12*, 733–750.

Renz M. and Breithaupt T., 1999. Population structure and habitat characteristics of the crayfish *Austropotamobius torrentium* in Southern Germany. *Freshwater Crayfish*, *12*, 940–941.

Renz M. and Breithaupt T., 2000. Habitat use of the crayfish *Austropotamobius torrentium* in small brooks and in Lake Constance, Southern Germany. *Bull. Fr. Pêche Piscic.*, 356, 139–154.

Stloukal E. and Harváneková M., 2005. Distribution of *Austropotamobius torrentium* (*Decapoda*: *Astacidae*) in Slovakia. *Bull. Fr. Pêche Piscic.*, 376-377, 547–552.

Streissl F. and Hödl W., 2002a. Growth, morphometrics, size at maturity, sexual dimorphism and condition index of *Austropotamobius torrentium* Schrank. *Hydrobiologia*, *477*, 195–199.

Streissl F. and Hödl W., 2002b. Habitat and shelter requirements of the stone crayfish, *Austropotamobius torrentium* Schrank. *Hydrobiologia*, *477*, 201–208.

Svobodová J., Štambergová M., Vlach P., Picek J., Douda K. and Beránková M., 2008. The impact of the water quality on the crayfish population in the Czech Republic, comparison with legislation of the Czech Republic. *Vodohospodářské technicko-ekonomické informace*, *50*, 4–5 [in Czech with English summary].

Troschel H.J., 1999. Distribution of crayfish species in Luxembourg. *Freshwater Crayfish*, *12*, 791–795.

Vlček V., Kestřánek J., Kříž H., Novotný S. and Píše J., 1984. Geographical lexicon of the Czechoslovakia. Water courses and reservoirs. *Academia*, *Prag*, 316 p.

Vogt G., Brandis D., Krüger Ch. and Breker C., 1999. Crayfish populations in the vicinity of Heidelberg (Germany, Baden-Württemberg). *Freshwater Crayfish*, *12*, 948–949.