BIOMETRY AND DEMOGRAPHY OF THE INVASIVE CRAYFISH *ORCONECTES LIMOSUS* IN THE CZECH REPUBLIC

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ABSTRACT

Biometry, population data and selected ecological parameters of populations of the spiny-cheek crayfish, *Orconectes limosus,* were measured to evaluate the differences between “marginal” (short-time, situated on margins of an area) and “residential” (long-term, well established inside an area) populations of this invasive crayfish. We selected three types of localities: 1. Large rivers – residential (Labe, Vltava); 2. Brooks (small and shallow running waters) – marginal; 3. Isolated standing waters – residential (old sandpits or flooded quarries). No significant differences in the total body length of crayfish were found between running and standing water localities as a whole, or between marginal and residential populations from running waters. There was, however, a low but distinct difference in the body weight between crayfish from brooks and other waters. Larger specimens (up to 116.5 mm in body length) were found only in isolated standing waters, whereas no crayfish longer than 100 mm were found in the rivers. The sex ratio of the crayfish was almost equal in rivers and isolated waters; males were more numerous in brooks. There was a significant difference between male and female body weight-length relations.

Key-words: *Orconectes limosus,* Czech Republic, biometry, ecology, populations.

BIOMÉTRIE ET DÉMOGRAPHIE DE L’ÉCREVISSE INVASIVE *ORCONECTES LIMOSUS* EN RÉPUBLIQUE TCHÈQUE

RÉSUMÉ

La biométrie, les données populationnelles et un choix de paramètres écologiques ont été mesurés chez des populations de l’écrevisse américaine, *Orconectes limosus,* afin d’évaluer les différences entre populations « marginales » (de durée courte, localisées en limite de l’aire de répartition de l’espèce) et populations « résidentes » (bien établies depuis longtemps dans l’aire de répartition) de cette espèce invasive. Nous avons sélectionné trois types de sites : 1. Grandes rivières – population résidente (Labe, Vltava) ; 2. Ruisseaux (petits cours d’eau peu profonds) – population marginale ; 3. Plans d’eau isolés – population résidente (anciennes exploitations de sable ou carrières inondées). Aucune différence significative n’a été trouvée en ce qui concerne la longueur totale des écrevisses entre les populations d’eau vives et celles d’eau stagnantes, ou entre les populations marginales et résidentes des eaux courantes. On a trouvé cependant une faible mais significative différence concernant le poids corporel des écrevisses des ruisseaux et celles des autres milieux. Les plus grands spécimens (jusqu'à 116.5 mm de longueur corporelle) ont été trouvés dans les eaux stagnantes, alors qu'aucun spécimen de plus de 100 mm n'a été trouvé en rivière. Les sex-ratio des écrevisses étaient équilibrés en rivière et dans les plans d'eau isolés, alors que dans les ruisseaux, les mâles étaient plus nombreux. Une différence significative a été observée entre le rapport poids-longueur des mâles et celui des femelles.

Mots-clés : *Orconectes limosus,* République tchèque, biométrie, écologie, populations.

INTRODUCTION

The American spiny-cheek crayfish *Orconectes limosus* is a widespread invasive species present in a large number of European countries (HOLDICH, 2003), and it is the most widespread crayfish of non-European origin in the Czech Republic (KOZÁK *et al.,* 2004; PETRUSEK *et al., in press*). Its greater tolerance to water pollution, high fecundity, and short life span (TROSCHEL and DEHUS, 1993; SCHULZ and SMIETANA, 2001) make this species highly adapted to life in wide environmental conditions, and together with its migratory ability allow it to easily invade new suitable localities. Additionally, its low susceptibility to the crayfish plague, and ability to carry the pathogen responsible, facilitate the replacement of native crayfish, especially the noble crayfish *Astacus astacus,* in European conditions (LEŃKOWA, 1962; HOLDICH, 1987). Therefore the ecology of invading *Orconectes* populations is of great interest.

The life history and ecology of this species has been studied in its original area of distribution (SMITH, 1981; MOMOT, 1988) as well as in areas of new introduction and secondary expansion in Europe (STYPIŃSKA, 1972, 1973, 1978; KOSSAKOWSKI, 1974; VAN DEN BRINK *et al.,* 1988).

Although data on growth and sizes of the species have been frequently presented in the literature, with agreement that *O. limosus* is a relatively small or medium-sized crayfish (e.g. KULMATYCKI, 1935; KOSSAKOWSKI, 1961; KRZYWOSZ *et al.,* 1995), there are only several more detailed studies dealing with wider aspects of the biometry of this species (KOSSAKOWSKI, 1962; JESTIN, 1979; STYPIŃSKA, 1978; STYPIŃSKA *et al.,* 1978; SCHULZ and ŚMIETANA, 2001).

O. limosus has spread relatively quickly in various surface waters in the Czech Republic (CR) during the last two decades (ĎURIŠ and KOZÁK, 2000; KOZÁK *et al.,* 2004; PETRUSEK *et al.,* in press). We may consider the populations of this invasive crayfish to belong to two different types, depending on the establishment status: the residential (long term, locally well-established inside the area occupied by the species), and the marginal populations (existing for a short-time, near the furthest distributional limits of the species expansion), in some respects similar to the categories of invasive crayfish populations used by LIGHT (2003). The aim of this study was to evaluate some aspects of the biology of *O. limosus,* and to examine differences in the weight and length biometric parameters of the populations noted above.

MATERIAL AND METHODS

Study sites

The study sites were located in the watersheds of the rivers Labe (Elbe) and Vltava, representing most part of *O. limosus* recent distribution in the Czech Republic (PETRUSEK *et al.,* in press). In total, we collected samples of *O. limosus* at 31 localities between 2003 and

2005. Additional data on crayfish were used from our previous survey in the Pšovka brook (right-side tributary of the river Labe near Mělník, two localities), 2001-2002, realized for MSc. thesis (VRZAL, 2002) under scientific guidance by the senior author (Z.Ď.). The following environmental parameters were measured using the field multimeter kit Multi 340i/SET (WTW Weilheim, Germany) (minimum-maximum, mean, respectively; the later not given for temperature) – in rivers: surface water temperature (6.5-24.9°C), pH (7.5-9.1, 8), conductivity (257-710, 467 μS.cm^{-1}), oxygen concentration (6.4-13.5, 10.2 mg.l^{-1}); in standing waters: surface water temperature (11.1-26.4°C), pH (7.7-8.7, 8.2), conductivity (479-1,020, 731 μS.cm^{-1}), oxygen concentration (7.7-15.5, 10.3 mg.l^{-1}). In selected running-water localities, we sampled the macrozoobenthos using a Surber's net covering 0.1 m^2 of the bottom for saprobic index analyses (results showed the levels of α- to β-mesosaprobity).

Catching and measuring crayfish

Individuals of *O. limosus* were caught mainly by hand in rivers and along the edge of reservoirs; scuba diving was used in isolated waters. In rivers and reservoirs, shallow waters with stones as shelters were examined by 3 persons for 1 hour, representing comparable sampling effort. Captured specimens were weighed using digital balances to the nearest 0.1 g, and their sex (M-male, F-female) was determined. The specimens from the brook Pšovka were caught by hand or by baited traps by D. Vrzal. All sampled specimens were preserved in alcohol and subsequently measured in the laboratory.

Post-orbital carapace length (POCL – measured from the posterior orbital margin to the posterior median edge of the carapace), rostrum length (RL – from the tip of rostrum to the posterior orbital margin), and chela length (CHL), chela width (CHW) and chela thickness (CHT), were measured to the nearest 0.1 mm using a beam caliper. Total length of the body (TL) was calculated from the combined length of the postorbital body length (PoTL – from the posterior orbital margin to the posterior telson margin, measured to the nearest mm) and the rostrum length (RL), and rounded to the nearest 0.5 mm. The number of eggs was counted in ovigerous females, and cheliped loss or regeneration to 75% of the normal cheliped growth was noted.

Selection of populations

To highlight and generalize studied biometric correlations, specimens were pooled for selected statistical analyses for the main groups of the crayfish populations – marginal and residential. (1) The "marginal" populations, in our opinion, represent the marginal parts of the area colonized by the species and show a tendency to spontaneously penetrate into yet unoccupied water bodies. One-way, upstream movement of the specimens should prevail in such a (migrating) population. (2) The "residential" populations, on the other hand, occupy long-term, well-established, main parts of the species area in the main rivers and lower parts of their tributaries. The continuous exchange of specimens from the lower and higher parts of a stream is assumed. The residential character should be expected also in the populations of *O. limosus* introduced by humans to isolated water bodies. No spontaneous migrations or exchange of specimens is possible there.

The samples were assigned to the following groups: (1) Larger rivers (Labe, Vltava) – residential; (2) Brooks (small and shallow running waters) – marginal; (3) Isolated standing waters (mainly old sandpits or quarries) – residential.

Statistical analyses

Differences in total body length in the main types of localities: The three main selected types of localities and the sex were used as factors for analysis (General Linear Model with program R). Growth classes of crayfish were analyzed for all crayfish collected in the selected water types, as well as separately for males and females in these waters.

Equality of the proportion of males and females in the sample was tested by the chi-square test.

Interaction between weight and total body length: 95% confidence intervals were used for correlation coefficients and comparison of regression parameters. The weight of each individual was transformed by the formula $w' = \sqrt[3]{w}$ for regression analyses (linear model) of the difference in male and female total body length and weight relationship.

Interaction between weight and total body length (or post-orbital body length and post-orbital carapace length, respectively): confidence intervals were calculated for each parameter for males, females, and both sexes pooled.

RESULTS

Demography and sizes

In total, 1,247 crayfish were captured during the survey in 2003-2005; additional analyses were conducted on the material from previous research in the brook Pšovka (2001-2002; VRZAL, 2003), with a total of 425 specimens. The data on sex are lacking for 61 juvenile specimens; the sex ratio of the remaining *O. limosus* in both sets was evaluated. The material from the 2003-2005 survey contained 586 males (49%) and 600 females (51%), including 37 ovigerous ones. The material from the brook Pšovka contained 347 males and 78 females (82 and 18%, respectively); of those only 4 were ovigerous.

The total length (TL) of the largest male in both datasets was equally 107 mm, and that of the largest female 116.5 and 102.5 mm, respectively. The heaviest male weighed 39.6 g (TL 106 mm) and 46 g (TL 107 mm), the heaviest female 49.2 g (TL 116.5 mm) and 33 g (TL 102.5 mm). The sex ratio (males: females) in the whole material available was 1.37: 1 (933: 678). The proportion of males in the material was significantly higher than the proportion of females ($\chi^2 = 41.69$, df = 1, $p < 0.001$). The sex ratio for pooled samples from large rivers was 1.12: 1 (162: 145), from isolated waters 1.05: 1 (79: 75), and from brooks (marginal populations, including Pšovka) 4.02: 1 (362: 90).

Ovigerous females were caught on May 13, 2000 (Pšovka, 4 females), May 20, 2004 (rivers Doubrava and Cidlina, 10 females), May 21, 2004 (Labe in Obříství, 14 females), May 22, 2004 (river Jizera near Nový Vestec, and Labe near Štětí, 5 females), June 11, 2004 (confluence of the brook Luční and the river Labe, Třeboutice, 1 female); May 28, 2005 (Lhota near Brandýs nad Labem, 7 females). The smallest ovigerous female had a total length of 46 mm, the largest 97.5 mm. The highest fecundity (564 eggs) was recorded for a female with TL 91.5 mm (Labe in Štětí, May 22, 2004). 29 ovigerous females were used for regression analysis of pleopodal fecundity. A significant relation ($p < 0.001$) was found between the number of eggs and total body length of females ($y = 6.0144x - 209.84$, $R^2 = 0.57$).

Cheliped loss

An important difference was found in the study of injured specimens. The rate of cheliped loss and/or cheliped regeneration (up to 75% of the normal cheliped length) differed among crayfish populations in the studied water types. Whereas 22% of crayfish collected from brooks (marginal populations) and 20% from isolated waters (residential populations) lacked or were regenerating at least one cheliped, this ratio was much lower in rivers (residential populations) – only 9%.

Length and weight relations

The analyses of the size classes based on the total body length (Figure 1) show a bimodal distribution of body length, with the modes of specimens 40-60 and 80-100 mm long from isolated waters, and 40-60 and 70-80 from rivers. A closer to normal distribution of growth classes was found in crayfish caught in brooks.

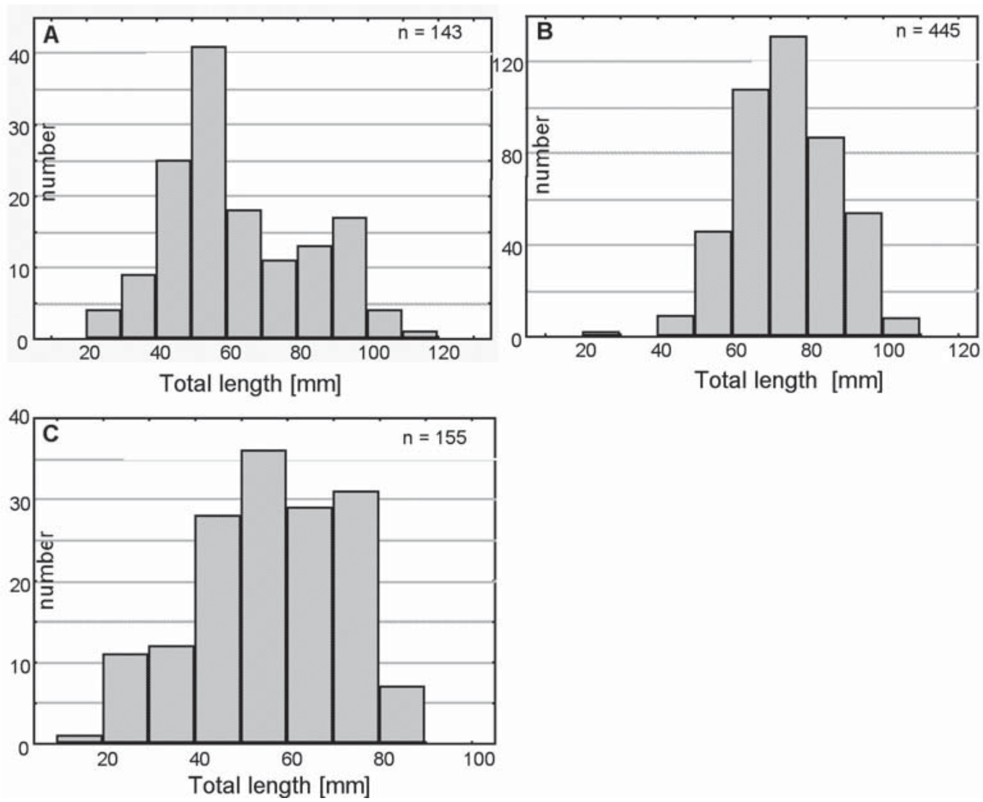

Figure 1

Growth classes of *O. limosus* caught in main water types. A) isolated waters, B) brooks, C) rivers.

Figure 1

Classes de croissance d'*O. limosus* capturées dans les principaux types de milieux. A) plans d'eau isolés, B) ruisseaux, C) Rivières.

Differences in the mean total body length of crayfish males and females in three main water types (Figure 2) were significant (GLM, $p < 0.001$). Marginal populations in brooks containing the largest crayfish (in the mean value) showed the highest difference in body length in comparison with populations from rivers and isolated waters (both residential). Males were larger than females (GLM, $p < 0.001$), especially in brooks and isolated waters, but smaller than females in large rivers. In the latter case, though, the difference was only minor. The larger individuals were not distributed equally among the water types; specimens exceeding 100 mm (see above) were caught mainly in isolated standing waters, and no specimen from the river Elbe exceeded this value.

The relation of wet weight of males and females to TL was different in various types of waters (Figure 3). Among factors influencing the weight of the crayfish, after body length, the type of water was more important than the sex of the individual. The highest weight/TL ratio was found in males and females from marginal populations (Pšovka and Hrejkovický brooks), where mean TL was also higher. Crayfish from isolated standing waters showed intermediate values; lowest values of weight/length were found for specimens from larger rivers (almost exclusively the Elbe), where the average body length was also lower, and males were smaller in comparison with crayfish from remaining water types (see above).

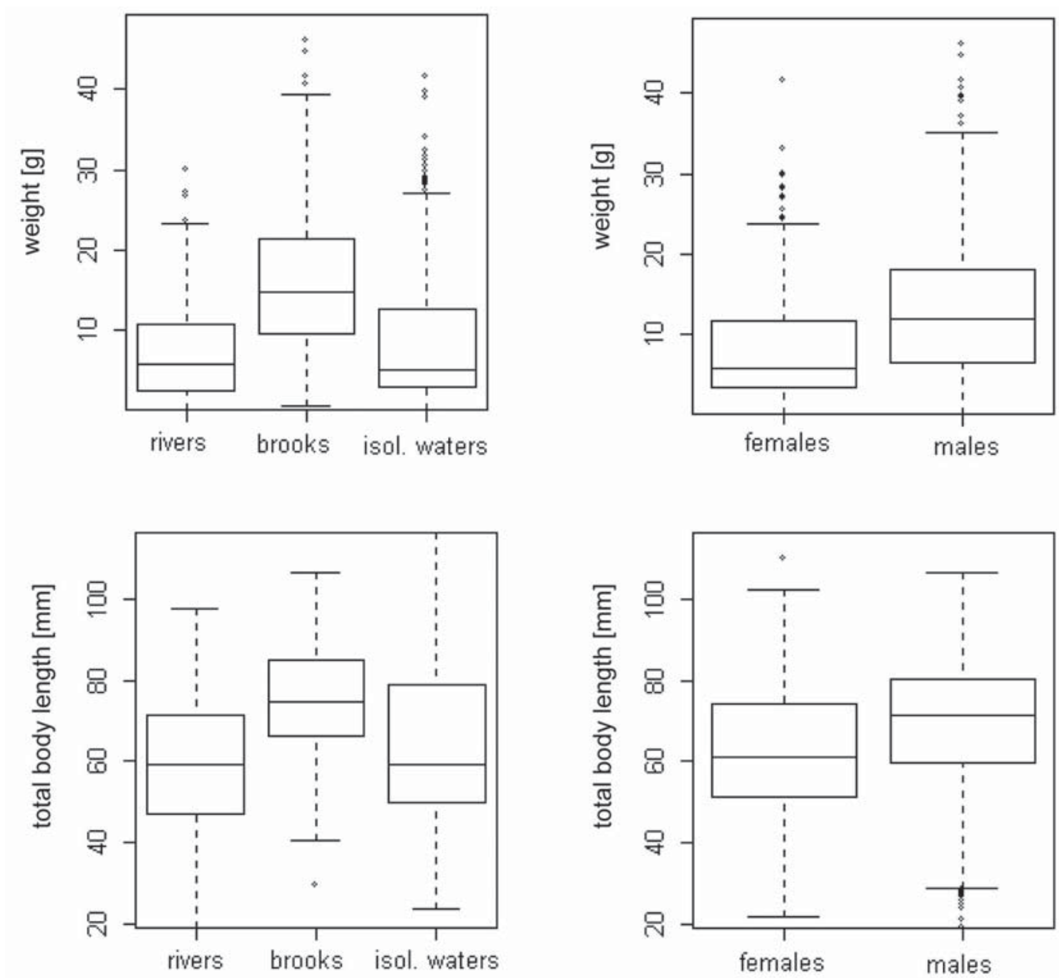

Figure 2

Box plots of weights and total body lengths of *O. limosus* caught in main water types, and in males and females from the whole material.

Figure 2

Boîtes à moustaches du poids et de la longueur corporelle d'*O. limosus* capturées dans les types principaux de milieux, et pour l'ensemble des mâles et des femelles échantillonnés.

Allometry

The regression analysis of weight vs. total length yielded regression coefficients indicating positive allometric growth in *O. limosus*. The weight-length relationship showed that in males, weight increased with body length significantly faster than in females. No significant increase in the slope of the regression of wet weight vs. total length was found for females exceeding 40 mm in length. Detailed examination of allometry in *O. limosus* based on weight (Figure 4) provided the following result: The confidence intervals and regression parameters for specimens with TL < 50 show similar growth curves for both sexes. The regression coefficients are similar in specimens with total body length 45-60 mm, but differ distinctly in crayfish longer than 60 mm. Both the parameters indicate a significant difference in the weight growth in males and females exceeding 60 mm in body length.

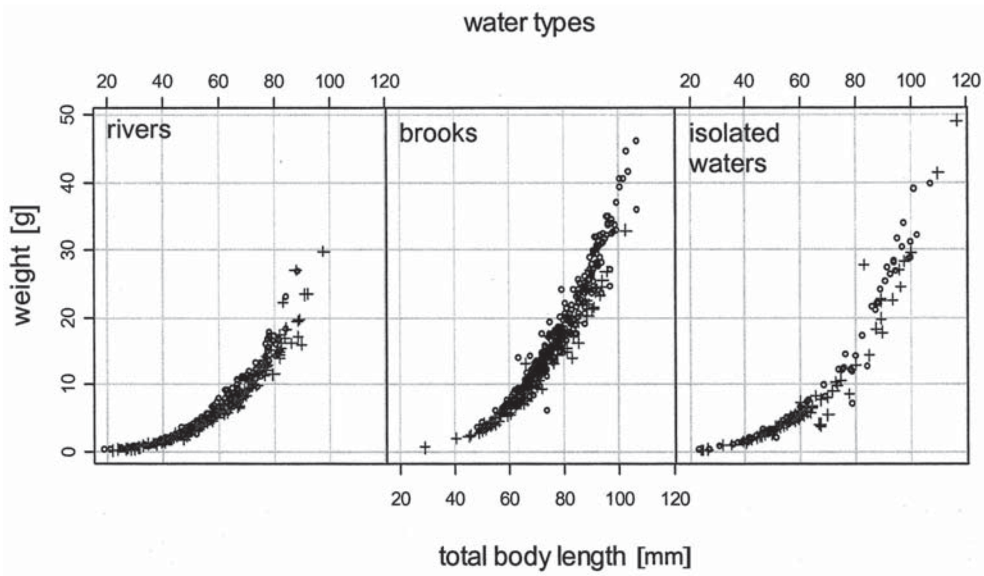

Figure 3
Variation of male (circles) and female (crosses) weights of *O. limosus* in main water types.

Figure 3
Variations du poids des mâles (ronds) et des femelles (croix) d'*O. limosus* dans les principaux types de milieux.

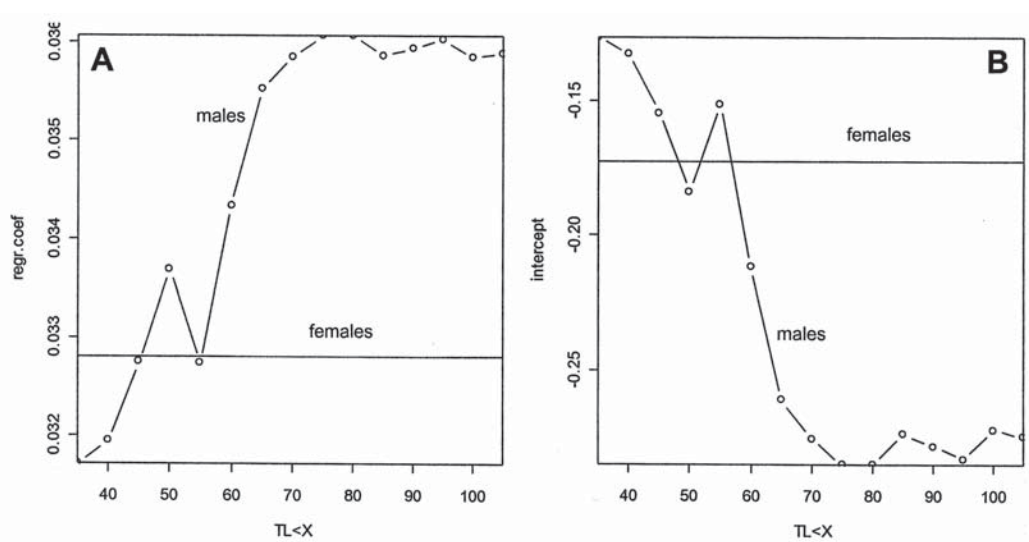

Figure 4
Regression coefficient and intercept of males with total body length TL < value on x-axis compared with regression coefficient for all females.

Figure 4
Coefficient de régression et intercept des mâles avec la longueur corporelle TL < valeur sur l'axe des x, comparée au coefficient de régression pour toutes les femelles.

Sex-specific differences were found in the growth of the chelae. The slope of the regressions of chela length/total length ratio increased 1.4 times for the largest males (~ 100 mm TL) and differed significantly from that of females and smaller males (Figure 5). In both sexes the square model of the chela length regressions to the total body length shows a higher value in comparison with the linear model, indicating a positive allometry for chela length increase (R^2 = 0.9304 for squared model and 0.908 for linear model in males; 0.9453 and 0.9289, respectively for females). Transformed chela length data ($y' = \sqrt[2]{y}$) was used for the linear R-squared model to evaluate confidence intervals for the regression coefficient for males and females (confidence level = 0.95): males 0.055-0.058, females 0.0402-0.0425 (intercept: males 1.044-1.227, females 1.447-1.599).

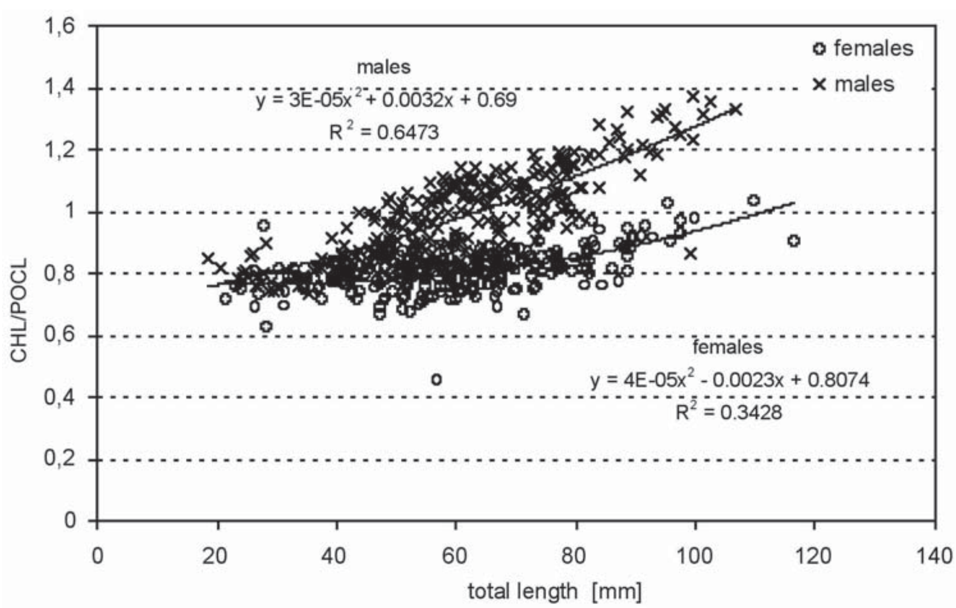

Figure 5
Ratio of the chela length CHL to the post-orbital carapace length POCL (y-axis) compared with the total body length (x-axis).

Figure 5
Ratio entre la longueur du chela CHL et la longueur post-orbitale de la carapace POCL (axe des y) comparées avec la longueur totale corporelle (axe des x).

The ratios of the chela width or the chela thickness to the total length increased less markedly with increased body length for both sexes in comparison with the chela length, and indicate negative allometry. The differences between sexes in these characters are significant but low.

Postorbital carapace length as the key biometric character

Weight, and particular length parameters related to total length of body (TL) or postorbital carapace length (POCL), showed that the latter is the most suitable parameter for biometric relations. Both parameters (TL and POCL) strongly correlate with each other in males (y = 0.3906x – 2.4827, R^2 = 0.9845) as well as in females (y = 0.3647x – 1.4767, R^2 = 0.9851). Comparison of the correlation between transformed weight and different length parameters – POCL and TL (Pearson correlation coefficient – 0.990 and 0.985, lower and upper limit of confidence intervals – 0.9891-0.9916 and 0.9827-0.9867, respectively,

Table I
Interaction between weight and either total body length (A) or post-orbital carapace length (B) in males and females of *O. limosus.*

Tableau I
Interaction entre le poids et, soit la longueur corporelle totale (A), soit la longueur post-orbitale de la carapace (B) chez les mâles et les femelles d'*O. limosus.*

A	males	females
Equation	$y = 0.0913x - 0.0310$	$y = 0.0898x - 0.0358$
Regression coefficient	(0.0902, 0.0923)	(0.0884, 0.0913)
Intercept	(0.0589, 0.0050)	(– 0.0686, 0.0031)
R^2	0.9804	0.9805
p-value	$p < 0.0001$	$p < 0.0001$

B	males	females
Equation	$y = 0.0358x - 0.2692$	$y = 0.0328x - 0.1725$
Regression coefficient	(0.0353, 0.0362)	(0.0322, 0.0334)
Intercept	(– 0.3029, – 0.2356)	(– 0.2122, – 0.1328)
R^2	0.9748	0.9749
p-value	$p < 0.0001$	$p < 0.0001$

p-value = significance of ANOVA.
R^2 = coefficient of determination.

with confidence level = 0.95) showed significant differences between POCL (which shows the highest correlation with weight), and other features mentioned.

Analyses of interactions between weight and either total body length (TL) or postorbital length of carapace (POCL) for males and females (Table I) show significant differences between parameters for both sexes in the case of TL, and an overlap of the intervals for regression coefficients as well as intercept in the case of POCL. It is likely that POCL is less variable for both sexes and better correlates with their weights than TL.

DISCUSSION

The spiny-cheek crayfish *Orconectes limosus* is, in comparison with other American species, a relatively small or mid-sized crayfish, measuring up to 50-54 mm in carapace length (CL, incl. rostrum), with an average life span of 2 years. One-year-old crayfish measure about 35 mm CL, while those with the age of two years measure 50 mm CL (HAMR, 2002). The maximum reported values are 61 mm for carapace length (CL) and 4 years for life span (MOMOT, 1988; HAMR, 2002). KOSSAKOWSKI (1961) also suggested, based on Polish material, that the maximum age of *O. limosus* is 4 years. The short life span in this species is compensated by a higher growth rate, as was demonstrated in a comparison of *O. limosus* with the narrow-clawed crayfish *Astacus leptodyctylus* (64.7 ± 0.9 mm and 44.8 ± 6.9 mm, respectively, in one-year old specimens – SCHULZ and SMIETANA, 2001). KOSSAKOWSKI (1961) defined the following size classes for 1 +, 2 +, 3 + an 4 + years old *O. limosus*, respectively: 40-65, 65-80, 80-95, 95-110. CHYBOWSKI (2000) found the largest specimens measuring 110 mm in males and 121 mm in females, and with weight 42.9 and 46.3 g., respectively; LEŃKOWA (1962) reported on a female 128 mm long. The present material agrees in these respects with literature data. The analyses of the total collection of specimens available yielded two main size classes of 40-60 and 70-100 mm long. Those sizes correspond with the one- and two-year, and partly also three-year old specimens, which were dominant in the present material. Higher size classes are less well represented, and decrease rapidly in abundance.

34 ovigerous females were collected during our survey from 13 May to 11 June in 2000-2004. Eggs are laid by *O. limosus* in May and egg carrying may prolong to June when hatching occurs (HAJER, 1994; HAMR, 2002). HOLDICH and LOWERY (1988) reported on a 45 mm long (carapace length) spiny-cheek crayfish with 400 eggs. MOMOT (1988) and STUCKI (2002) counted 163 or 139 eggs (respectively) as the mean number of attached eggs in this species. HAMR (2002) collected data of several authors and reported on pleopodal fecundity ranging between 57 and 440 eggs, which correspond also with the report of STYPIŃSKA (1973) and STRUŹYNSKI (2002). STUCKI (2002) found a wider range – between 31 and 555 eggs. KOZÁK *et al.* (in press) found an average number of 217 eggs on pleopods in their females of *O. limosus* from the Czech Republic, and refer to a range of 95-492 eggs. A maximum of 500 eggs were reported by STYPIŃSKA (1972). The maximal number in our material was 564 eggs, which belongs among the highest values recorded for this species. The high fecundity of *O limosus*, as well as the fast juvenile growth noted above, were suggested by TROSCHEL and DEHUS (1993) and SCHULZ and SMIETANA (2001) to be additional important factors making *O. limosus* competitively superior over European native species under certain conditions, in addition to other aspects widely discussed in the literature (HOLDICH, 1987).

The sex ratio is similar in crayfish from both large rivers and isolated waters occupied by the “residential” populations of *O. limosus* in the Czech Republic. This is in contrast with the material from the brook Pšovka with a “marginal” type of crayfish population. The number of males collected in the latter locality exceeds the number of females more than 4 times. This may be partially caused by the different collection method, as the high number of males may reflect higher activity in males, causing them to enter the baited traps more frequently than females. However, samples collected in this brook recently by hand (PETRUSEK, unpublished data) also showed a very high bias towards males.

The mean size and weight of males and females of the Pšovka population is also higher than in the other two types of waters, which may be also partly affected by the collecting method. That, however, cannot explain the higher weight to length ratio in the samples from the brook Pšovka. Although the weight-length relations significantly differ in males and females, the influence of water types on the weight of crayfish is more important, as seen in this report. This actually means that the body condition in such a marginal population may be better than in other water types. Benthic invertebrates and plants in brooks (VRZAL, 2002) may provide a more accessible and abundant food basis for crayfish in comparison with isolated standing waters or rivers. Water turbidity is less affecting for crayfish in brooks, with their lentic environments alternating with lotic parts, while in rivers the crayfish may be under continuous influence of the current. The energetic demands needed to overcome the current, together with lower food supply (although the zebra mussel *Dreissena polymorpha* is often abundant in the river Labe) caused smaller growth in crayfish. On the other hand, the marginal crayfish populations in brooks are more concentrated in narrow streams and the intraspecific competition may result in a higher activity of larger-bodied specimens, as shown in the average body lengths of trapped specimens in this report, and in the higher percentage of cheliped loss in crayfish. Such cheliped loss, indicating the level of intraspecific competition, was shown for *A. astacus* in Scandinavia (SKURDAL *et al.,* 1988) and for *Procambarus clarkii* in North America (POWELL *et al.,* 1998). Cheliped loss is also important in isolated standing waters. Most of them are sand pits with limited hiding places and hard substrates (ĎURIŠ *et al,* in press), which, despite stagnant waters and moderately abundant food (zebra mussel, water algae and water macrophytes, etc.) resulting in larger bodies, lead to increased intraspecific competition. Shelter limitation and starvation are the main factors affecting fighting, cheliped loss and cannibalism in crayfish (WESTMAN, 1973; ACKEFORS *et al*., 1989*;* KOZÁK *et al.*, 2002).

Analyses of the weight-length relationship of *O. limosus* revealed that males gained weight with increasing length faster than females. Similar relations were found for *Pacifastacus leniusculus* by MASON (1979) and *Austropotamobius torrentium* (STREISSL and HÖDL, 2002). Our results reveal that males and females of a total length up to 60-65 mm share similar growth curves, but that these differ distinctly for longer specimens. Positive allometric growth relating to the total length was also found in the wet weight and the chela lengths in males over 40-50 mm in the present material. For males this fact can be explained by the positive allometric growth of chelae, whereas the growth of female chelae is nearly isometric. The positive allometry in the growth of chelae correlated to the sexual maturity of male crayfish (KOSSAKOWSKI, 1961; SCHULZ and SMIETANA, 2001; HAMR, 2002). The body length analyses show that in *O. limosus* the allometric growth may occur in different body parts of mature males independently and at different ages. In particular, the chela length and the body weight show different growths in both sexes from about 40 mm of body length, while the body length itself is subequal in males and females up to 60 mm of body length, and only then significantly differ. These size classes correspond to ages of about one and two years, respectively (see above). It is likely that the body weight in mature males is influenced largely by quickly growing chelae rather than by increased total length. No allometry was, however, found for the chela width or the chela thickness in the present material of *O. limosus*, which differs, for example, from *A. torrentium* (STREISSL and HÖDL, 2002).

The total number of 1,672 spiny-cheek crayfish specimens analyzed during the present research, although important, consists of two larger collections of several hundreds crayfish, and a series of minor samples from numerous (about 30) localities. As usual, only some specimens, rarely up to 20 individuals, were caught during our survey despite intensive examination of embankment environments. The samples were much more limited than expected from our previous experience with comparable sampling effort, and when compared with published (HAJER, 1994) or personal reports. The dramatic overall decrease in abundance of *O. limosus* in Czech waters was surprising. In Czechia, this decrease corresponds well with the catastrophic flood in the summer 2002, which affected watersheds of both the rivers Vltava and Labe (Elbe), the central axes of the spiny-cheek crayfish distribution in the country (PETRUSEK *et al.,* in press). Together with increased water velocity and the mechanic impact of material carried by the flood, the dispersed sediments decreased water quality. All these factors had strong impacts on aquatic communities, probably reducing the crayfish populations by both direct and indirect effects. A similar decrease of spiny-cheek crayfish density was also observed in Poland (KRZYWOSZ, 2004), a country also widely flooded in 2002. However, a *O. limosus* abundance decrease was reported also from northeastern Poland, an area unaffected by floods. The real causes of this phenomenon are therefore unclear.

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