DOI: 10.7251/QOL2001011R **UDC:** 595.76:591.139(282.243.743)

Original scientific paper

Investigations of Variability of Morphometric Characteristics in Stone Crayfish in Order to Preserve Autochthonous Genome

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Abstract: This paper presents the information about morphological variability and sexual dimorphism of the stone crayfish (*Austropotamobius torrentium*) in the area of Korana River in Mrkonjic Grad. The crayfish were caught by hand made baited traps from October 2018 to May 2019. A total of 46 crayfish were caught, of which 33 males and 13 females. The dimensions of eight morphometric characteristics: body weight (W), body length (TBL), rostrum length (ROL), rostrum width (ROW), claw length (CLL), carapace length (CPL), carapace width (CPW) and abdomen length (ABL), were analyzed, both in males and females. Also, the body condition was determined for all individuales. The measurements results of morphometric characteristics partially matched into the alredy known range of variations. These data presens first ones for the observed area. By using Mann-Whitey U-test, it was noted that there are significant differences between the sexes for W, TBL, CLL, CPL, CPW and ABL. These resuls could be explained by sexual dimorphism of the stone crayfish.

Key words: stone crayfish, morphometric characteristics, sex dimorphism, Korana River, Mrkonjic Grad

INTRODUCTION

Given the previous researches in European countries, we found different autochthonous species in different areas (Trožić-Borovac et al., 2007). Therefore, an existence of four autochthonous crayfish species is confirmed in Bosnia and Herzegovina: *A. astacus, A. leptodactylus*, *A. torrentium* and *A. pallipes* (Karaman, 1976; Trožić-Borovac, 2011). *A. torrentium* has a narrow ecological valence and hardly adapts to environmental changes, which is a main reason for being endangered. This is one of two species from the *Austropotamobius* family inhabited in Bosnia and Herzegovina, mostly found in small streams in a mountain zone. Mountain habitats of the species *A. torrentium* have not been studied well yet. Study of autochthonous crayfish species is considered very significant because an appropriate knowledge is required for their protection and preservation. Further, autochthonous species cover limited area in particular they are related to small portions of aquatic habitats. Their role is to maintain the balance in aquatic ecosystems. Nevertheless, besides their high significance a little is yet known about crayfish that results in inadequate attention to their protection.

Namely, the study of stone crayfish population structure provides significant information on certain waters and water management manner (Trožić-Borovac et al., 2007; Trožić-Borovac et al., 2012; Rajković, 2012). These parameters are also important as many authors (Huber and Schubert, 2004; Rajković, 2012) consider morphometric parameters along with specific genetic features to be an indicator of specific features in certain crayfish population.

Previous studies are very important for examining variability of stone crayfish morphometric features (Trožić-Borovac et al. 2007; Rajković, 2012; Dakić and Maguire, 2016), and provide a good grounds for evaluating variability of morphological features within different populations as well as presenting strategies for sustainable management of autochthonous crayfish gene.

The aim of the study is to determine principal morphometric features, mass, the Fulton's condition factor and length-weight relationship of decapod crustaceans in the *Austropotamobius torrentium* species from the Korana river. According to IUCN criteria the latter was assigned the DD (Data Deficient) category for the European region (Füreder et al., 2010), and is listed on the national Red List of Bosnia and Herzegovina as endangered species VU (Vulnerable).

MATERIALS AND METHODS

The nets and LiNi trap with baits were used to collect stone crayfish specimens (Westman *et al.,* 1978). Given that the traps for crayfish hunting are selective for the size of specimen (Hogger, 1988), almost all of the hunted specimens of stone crayfish were larger than 70 mm (Souty-Grosset et al., 2006). All the crayfish were caught at twilight, between 06:00 p.m. and 10:00 p.m.

The values of the main morphometric features were determined in all evaluated specimens: body length (TBL), rostrum length (ROL), rostrum width (ROW), claw length (CLL), carapace length (CPL), carapace width (CPW) and abdomen length (ABL). In addition, the values of body weight (W), Fulton's condition factor (FCF) and Decapoda crayfish constants (CC) are determined.

Two condition indices (adopted from Streissl and Höld, 2002) were calculated**:**

Fulton's Conditions Factor (FCF):

$$FCF = \frac{W}{TBL^3}$$

Where: W – total weight, TBL – total length

$$CC = \frac{W}{TBL \times CPL \times CPW}$$

Where: W – total weight, TBL – total length, CPL – carapace length, CPW – carapace width (Streissl and Höld, 2002).

For the mass determination, a weighing scale of type "Kern" (Kern PFB Version 2.2) max. weighting 1200 g with an accuracy of 0.01 g is used, and morphometric measures were taken using a caliper gauge (made by Stainless Hardened) with an accuracy of 0.02 mm. All information is processed by using the Microsoft Office Excel and Statistic 5.

RESULTS

Among the total of 46 analyzed specimen it is found that 33 (or 71.74%) were males and 13 (or 28.26%) were females (sex ratio was aprroximately 1.4 : 1).

Measurement results for morphometric parameters at the stone crayfish specimen from the Korana river are presented in tables as mean value, minimum (min), maximum (max), standard deviation (SD) and coefficient of variation (CV).

The values obtained for male specimens (Table 1) show that an average body weight was 15.72 g, an average body length was 68.38 mm, the rostrum length was 7.79 mm, the width was 5.87, the claw length was 26.79 mm, the carapace lentgh was 26.2 mm, the carapace width was 18.42 mm and the abdomen lenth was 31.15 mm. On basis of the said values a standard deviation (SD) is obtained and had the greatest value for total body length (13.98), slightly smaller value for body mass (10.23) and even smaller for claw lentgh (7.48), abdomen length (7.43), carapace length (6.22), carapace width (4.72), and the smallest is for length

(1.85) and width (1.72) of rostrum. Majority of analyzed morphometric features is moderately variable (CV 20%-30%, Table 1); only morphometric feature W (CV=65.07%) at male specimen demonstrates a high variability (CV>30%).

Table 1. Descriptive statistics- mean value, standard deviation, ranges of measured morphometric characteristics for males of species *A. torrentium* from the Korana River

Variable	Mean	Min	Max	SD	CV
W	15.72	1.2	45.32	10.23	65.07
TBL	68.38	41.0	96.82	13.98	20.45
ROL	7.79	5.0	10.88	1.85	23.73
ROW	5.87	3.29	10.1	1.72	29.24
CLL	26.79	12.58	38.8	7.48	27.92
CPL	26.2	10.0	38.85	6.22	23.76
CPW	18.42	9.0	29.3	4.72	25.62
ABL	31.15	9.2	40.0	7.43	23.86

Values obtained for female specimens (Table 2) show an average body weight of 6.61 g, 61.89 mm, the rostrum length 7.33 mm, the rostrum width 4.9 mm, the claw length 20.54 mm, the carapace length 21.36 mm, the carapace width 15.04 mm and the abdomen length 26.66 mm. Given these values the standard deviation (SD) is obtained with the maximum value for total body length (5.02), claw length (5) and abdomen length (4.84), significantly small for carapace length (2.90), body mass (2.89), carapace width (1.89), and the least is for the rostrum length (0.98) and width (0.95). The only firm feature (CV<10%) at female specimens showed morphometric label TBL (CV=8.12). ROL, ROW, CPL, CPW and ABL are included in low variable feature (CV 10%-20%). CLL (CV=24.34) is included in moderately variable feature (CV 20 % - 30 %) and one morphometric feature W (CV = 34.64%) demonstrates high variability (C.V. > 30%).

Table 2. Descriptive statistics- mean value, standard deviation, ranges of measured morphometric characteristics for females of species *A. torrentium* from the Korana River

Variable	Mean	Min	Max	SD	CV
W	6.61	3.3	11.0	2.29	34.64
TBL	61.89	51.0	71.01	5.02	8.12
ROL	7.33	5.0	8.03	0.98	13.35
ROW	4.9	3.98	7.0	0.95	19.36
CLL	20.54	13.35	30.72	5.0	24.34
CPL	21.36	16.28	26.04	2.9	13.59
CPW	15.04	10.0	18.0	1.89	12.57
ABL	26.66	18.96	31.35	4.84	18.15

Statistically, males and females significantly differ ($p<0.05$) in five morphometric features. These are: W ($p=0.004$), CLL ($p=0.016$), CPL ($p=0.003$), CPW ($p=0.027$) and ABL ($p=0.019$). No statistically significant difference ($p>0.05$) is found for TBL ($p= 0.064$), ROL ($p=0.558$) and ROW ($p=0.118$) (Table

3). Comparing mean values of abdomen length, rostrum length and width between sexes, it is observed that stone crayfish males have higher mean value for previously stated morphometric features compared to females, but it makes no significant difference in statistical terms.

Table 3. Significance of differences between mean values of morphometric characteristics of crustaceans species *A. torrentium* from the Korana River

Variable	U	Z	p
W	95.0000	2.915285	0.003554
TBL	138.5000	1.854072	0.063730
ROL	190.5000	0.585496	0.558214
ROW	150.5000	1.561324	0.118448
CLL	115.5000	2.415173	0.015728
CPL	91.5000	3.000669	0.002694
CPW	124.0000	2.207810	0.027258
ABL	118.0000	2.354184	0.018564

In the course of statistical data processing the correlation between total body length and weight of males (94.3%) and females (88.23%) (Figure 1) is found. It shows that longer body length means bigger body mass of specimens.

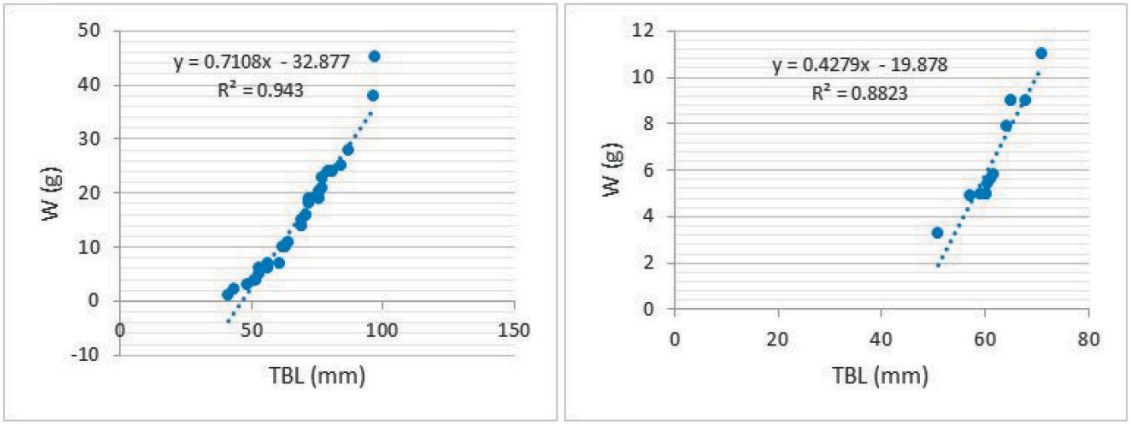

Figure 1. The ratio of body length and body weight of males (left) and females (right) of Danube crayfish

The correlation between body weight and claw length at male and female specimens (Figure 2) is made. It is found that a positive correlation is present and the body weight follows claw growth. Correlation coefficient is 89.67% at male specimens and 91.56% at female specimens.

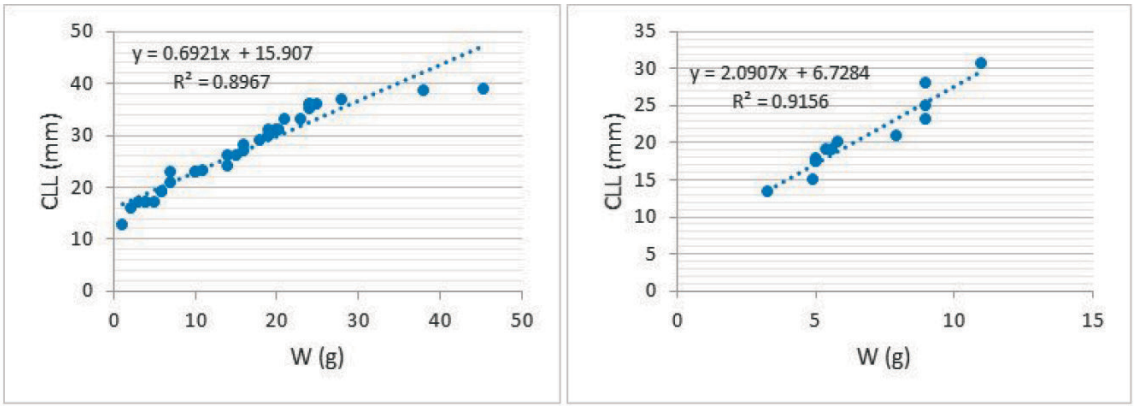

Figure 2. Relation of body weight and claw length in males (left) and females (right) of Stone crayfish

Based on correlation coefficient we may conclude that application of regression analysis makes coefficient highly significant in statistical terms between carapace width and body lenght. Correlation coefficient is 96.6% at male and 90.76% at female specimens (Figure 3).

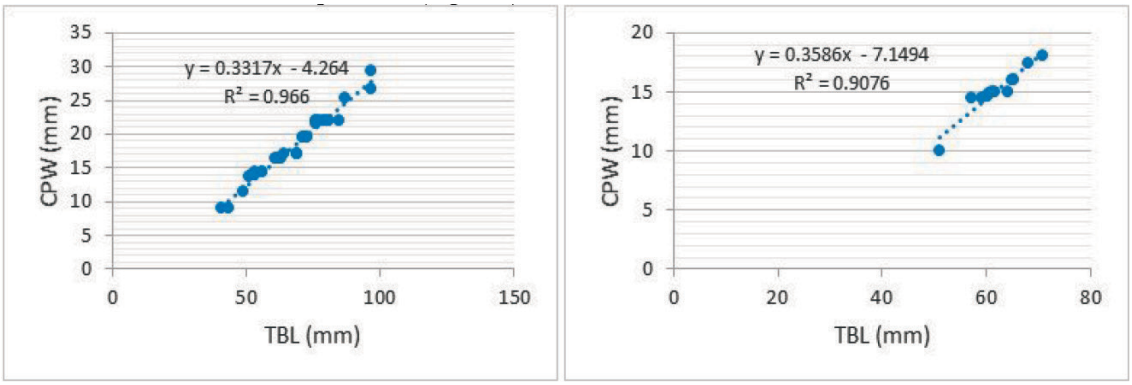

Figure 3. The ratio of body length and width of a carapace in males (left) and females (right) of Stone crayfish

The lowest CC is 0.265 and the highest is 0.476 (at male specimens). Mean value is 0.323 for female and 0.401 for male specimens. The least FCF is 0.017 and the highest is 0.051 (at male specimens). Mean value is 0.027 at female and 0.041 at male specimens (Table 4).

Table 4. Values for condition factor for Stone crayfish specimen

Variable			**FCF**		
Sex	Mean	Min	Max	SD	CV
M	0.041	0.017	0.051	0.008	19.78
F	0.027	0.023	0.033	0.004	13.22
Variable			CC		
Sex	Mean	Min	Max	SD	CV
M	0.401	0.265	0.476	0.058	14.35
F	0.323	0.271	0.376	0.034	10.60

DISCUSSION

An analysis of the results shows that a total body length of *A. torrentium* from the Korana river ranged from 51 mm to 71.01 mm at female specimens, and from 41 mm to 96.82 mm at male specimens. According to information found in related literature an average body length of the stone crayfish *Austropotamobius torrentium* in Italy is 80 mm, rarely reaches 120 mm (De Luise et al., 2004). The longest specimen from Croatia (Dakić and Maguire, 2016) was a male long 110.22 mm, and the longest female specimen had a total body length of 103.74 mm. Rajković (2012) reported a maximum total body length of 99.5 mm for female specimen and 85.4 mm for male specimen in Montenegro. The stone crayfish in the Bosnia and Herzegovina's waters had significantly smaller values of a total body length and maximm value was 70 mm both at male and female specimens (Trožić-Borovac et al., 2007).

In a sample from the population in the Korana river upstream the values of body mass ranged from 3.3 g to 11 g at female specimens and from 1.2 g to 45.32 g male specimens. Rajković (2012) reported body mass values for subadults and adults ranging from 1.2 g (at female specimens) to 48.6 g (at male specimens). Dakić and Maguire (2016) studied body mass of pregnant female specimen where the highest mass found was 43 g and the smallest one was 9 g.

Rostrum length at the analysed specimens from the Korana river ranged from 5 mm to 8.03 mm at female specimens, and from 5 mm to 10.88 mm male specimens. The mean value of rostrum length at the analysed specimens from the Korana river (7.32 mm F, 7.79 mm M) matches data provided by Rajković (2012) for the stone crayfish found in Montenegro. A specified average rostrum width at female (4.9 mm) and male specimens from this species (5.87 mm) does not significantly differ from mean values of the same feature of the species studied in Bosnia and Herzegovina (Trožić-Borovac et al., 2007).

Scope of change in carapace width is determined in Montenegro and ranges from 10.21 mm to 20.99 mm for female specimens and from 10.65 mm to 21.49 mm male specimens (Rajković, 2012).

It is determined that carapace size of the stone crayfish in Bosnia and Herzegovina ranges from 21 mm to 34 mm at female specimens and from 15 mm to 33 mm at male specimens and carapace width ranges from 10 to 18 mm at female specimens and from 9 to 22 mm at male specimens (Trožić-Borovac et al., 2007). In a sample from the Korana river downstream population the scope of change in carapace size matches the data given above.

The abdomen length of the said crayfish ranged from 9.2 mm at female specimens to 40 mm at male specimens. These records partially resemble the data from books as, according to Rajković's opinion (Rajković, 2012), these data usually fluctuates from 12 mm to 30 mm.

CONCLUSION

Morphometric features of the stone crayfish (*A. torrentium*) from the Korana river near Mrkonjic Grad were observed.

Eight morphometric features and two condition factors were analyzed on all 46 specimen (33 male and 13 female).

Values obtained for the stone crayfish morphometric features in Mrkonjic Grad area partially fit into the known scope of variability and represent first data for the Republic of Srpska.

The presence of statistically significant differences between adults in terms of their body mass, claw length, carapace length and width and abdomen length is confirmed, which is explained by emphasized sex dimorphism of the stone crayfish.

The data presented in this paper can serve as a basis for further studies of the *A. torrentium* species in this area.

ACKNOWLEDGEMENT

The paper presents the result achieved by realization of Program for the conservation and sustainable use of genetic resources of Republic of Srpska, financed by the Ministry of Scientific and Technological development, Higher Education and Information Society performs of the Republic of Srpska and implemented by the Institute of Genetic Resources of the University of Banja Luka.

Expert opinion on the research of biodiversity was issued by the Republic Institute for the Protection of Cultural, Historical and Natural Heritage (No. 30 / 625-723 / 18, 09.10. 2018th year; number 07/1.30/625-020/19, dated 23.1. 2019).

REFERENCES

Bedjanič, M. (2004). Novi podatki o razširjenosti raka navadnega koščaka *Austropotamobius torrentium* (Schrank, 1803) v Sloveniji (Crustacea: Decapoda). *Natura Sloveniae*, 6(1): 25-33.

Bertok, M., Budihna, N., Povž, M. (2003). Strokovne osnove za vzpostavljanje omrežja Natura 2000: ribe (Pisces), piškurji (Cyclostomata), raki deseteronožci (Decapoda): Končno poročilo. Naročnik: Ministrstvo za okolje, prostor in energijo, ARSO. Zavod za ribištvo Slovenije, Ljubljana, 370.

Crnogorac, Č., Trbić, G., Rajčević, V., Dekić, R., Pešević, D., Lolić, S., Milošević A. i Čelebić, M. (2013). Riječna mreža opštine Mrkonjić Grad - fizičkogeografska i ekološka istraživanja. Geografsko društvo Republike Srpske. 147.

Dakić, L., Maguire, I. (2016): Year cycle and morphometrical characteristics of *Austropotamobius torrentium* from two karstic rivers in Croatia. Nat. Croat., Vol. 25, No. 1, 87–100, 2016, Zagreb.

De Luise, G., Liberato, C., Di Cristo, C., Di Cosmo, A., Paolucci, M. (2004): Population analysis of Austropotamobius torrentium in the Friuli Venezia Giuli Region. Dept of Biological and Enviromental Sciences, Faculty of Sciences, University of Sannio, Benevento.

Füreder, L., Gherardi, F., Souty-Grosset, C. (2010). Austropotamobius torrentium (errata version published in 2017). The IUCN Red List of Threatened Species 2010: e.T2431A121724677. Downloaded on 25 August 2019.

Hogger, J.B. (1988). Ecology, population biology and behaviour. U: Holdich, D.M. i Lowery,R.S. (ur.), Freshwater crayfish: Biology, Management and Exploitation, The University press, Cambridge, 114-144.

Huber, M. G. J., Schubart, C. D. (2004). Genetic analysis of the stone Crayfish (*Austropotamobius torrentium*) in Germany on the local distribution around Regensburg and the impact of alien crayfish species. Universität Regensburg Leehrstuhl Zoologie, Regensburg.

Karaman, M. (1976). Fauna na Makedonija. Desetonogi rakovi-Decapoda (Malacostraca –Crustacea). Prirodonaucen muzej –Skopje.

Rajković, M. (2012). Distribucija, filogenija, ekologija i konzervacija rakova iz familije Astacidae na području Crne Gore. Doktorska disertacija. Prirodno- matematički fakultet, Univerzitet u Kragujevcu.

Souty-Grosset, C., Holdich, D.M., Noel, P.Y., Reynolds, J.D., Haffner, P., (ur.) (2006). Atlas of crayfish in Europe. Muséum national d'Histoire naturelle, Paris, France, 187.

Trožić-Borovac S., Nuhefendić I., Gajević M. and A. Imamović (2012). Morphometric characters of *Astacus astacus* L. (Astacidae) from the Praca river. „Radovi Šumarskog fakulteta Univerziteta u Sarajevu – Works of the Faculty of Forestry University of Sarajevo, Volume 42, Issue 1, 2012 (1-10) UDK 595.384.1(282) (497.6 Prača).

Trožić-Borovac, S. (2011). Freshwater crayfish in Bosnia and Herzegovina: the first report on their distribution. Knowledge and Management of Aquatic Ecosystems, 401, 26.

Trožić-Borovac, S., Deljanin, L., Dautbašić, M. (2007). Ekološko-biosistematske karakteristike potočnog raka *Austropotamobius torrentium* (Shrank, 1803.) iz Nahorevskog potoka, Radovi Šumarskog fakulteta, 1, Univerzitet u Sarajevu, 39−55.

Westman, K., Pursiainen, M. and R. Vilkman (1978). A new folding trap model which prevents crayfish from escaping. Freshwater Crayfish, 4: 235–242.

Recived: September 10, 2019
Accepted: November 19, 2019