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Dob i rast ilirskog klena *Squalius illyricus* iz rijeke Cetine

Goran JAKŠIĆ¹, Margarita MARUŠKIĆ KULAŠ¹, Krešimir KURI¹, Juraj PETRAVIĆ¹, Marin JARNJAK¹, Karla ŽELJKOVIĆ², Marina PIRIA²

¹Javna ustanova Akuatika-slatkovodni akvarij Karlovac, Branka Čavlovića Čavleka 1a, 47000 Karlovac, Hrvatska (e-mail: gjaksic@aquariumkarlovac.com)

²Sveučilište u Zagrebu, Agronomski fakultet, Svetošimunska 25, 10000 Zagreb, Hrvatska

Sažetak

U Hrvatskoj, ilirski klen *Squalius illyricus* endem je jadranskog slijeva, a obitava u rijekama Cetini i Krki. U posljednjih 20-ak godina istraživanja na ovoj vrsti nisu napravljena, a s obzirom na uski areal njegova staništa važno je pratiti stanje populacija. Za potrebe ovog istraživanja u travnju 2018. godine prikupljena je 41 jedinka iz rijeke Cetine te je prikazan njihov alometrijski rast, kondicijsko stanje i dob. Rezultati ukazuju na skoro izometrijski rast jedinki što ukazuje da navedeno stanište ima povoljne uvjete za njihov opstanak. Prosječna vrijednost Fultonova faktora kondicije iznosi 1,21 i stabilna je kod manjih i većih jedinki. Utvrđene su isključivo jedinke starijih dobnih skupina od IV do VIII što upućuje da su se jedinke grupirale za mrijest ili da su lovljeni veći primjerci uslijed korištenja mreže većeg oka. S obzirom da su u rijeku Cetinu uneseni strani predatori, potrebno je pažljivo pratiti trendove njihovih populacija i vršiti redoviti monitoring.

Ključne riječi: ilirski klen, endemska vrsta, alometrijski rast, kondicija, dob

Uvod

Ilirski klen *Squalius illyricus* endem je jadranskog slijeva koji u Hrvatskoj živi u slijevu rijeka Cetine i Krke (Mrakovčić i sur., 2006.; Čaleta i sur., 2015.). Prema Crvenoj knjizi slatkovodnih riba Hrvatske smatra se osjetljivom vrstom (Mrakovčić i sur., 2006.), dok je na Crvenoj listi IUCN-a uvršten u kategoriju gotovo ugroženih vrsta (Crivelli, 2006.). U literaturi se spominje njegova prisutnost u rijekama Krupi (Kolombatović, 1907.) i Zrmanji (Vuković, 1982.), međutim ti podaci nisu pouzdani (Bogutskaya i Zupančić, 1999.). Spominje se i u vodotoku rijeke Soče u Italiji i Sloveniji (Günther, 1868.; Munda, 1926.; Gridelli, 1936.), no točnost i tih podataka je upitna (Čaleta i sur., 2015.) jer ondje nije zamijećen još od 1850. godine (Kottelat i Freyhof, 2007.). Područje rasprostranjenosti ilirskog klena obuhvaća vodotoke srednje Dalmacije, i to slijev rijeke Cetine te gornje i srednje dijelove rijeke Krke (Čaleta i sur., 2015.). Može narasti do 40 centimetara (Habeković, 1994.) te doseći dob od VIII godina (Habeković, 1994.; Popović, 1994.). U istraživačke svrhe, ilirski klen iz rijeke Cetine nije ulovljen od 1986. godine, a zbog različitih ugroza u posljednje vrijeme koje prijete njegovu opstanku, kao što je unos stranih predatorskih ribljih vrsta (Piria, 2018.), važno je pratiti stanje njegovih populacija. Stoga je cilj ovog rada odrediti kondicijsko stanje, dužinsko-masene odnose i dobnu strukturu na populaciji ilirskog klena iz rijeke Cetine te dobivene rezultate usporediti s prijašnjim.

Materijal i metode

Uzorci analizirani u ovom radu prikupljeni su u travnju 2018. godine iz rijeke Cetine u mjestu Blato na Cetini električnim agregatom tipa Hans Grassl 1,20 kW (Halačka i Jurajda, 1994.). Veličina oka mrežice na anodi iznosila je 0,60 mm - 0,80 mm. Na terenu je izmjerena totalna dužina L tijela milimetarskim papirom uz točnost od 0,10 cm, kao i masa W elektronskom vagom "Kern" tipa 440-33N s preciznošću od 0,10 g. Sve prikupljene i analizirane jedinke su neozlijeđene puštene natrag u rijeku Cetinu.

Kondicijsko stanje analizirano je pomoću Fultonovog faktora kondicije K (Ricker, 1975.):

$$K = \frac{W}{L^3} \cdot 100$$

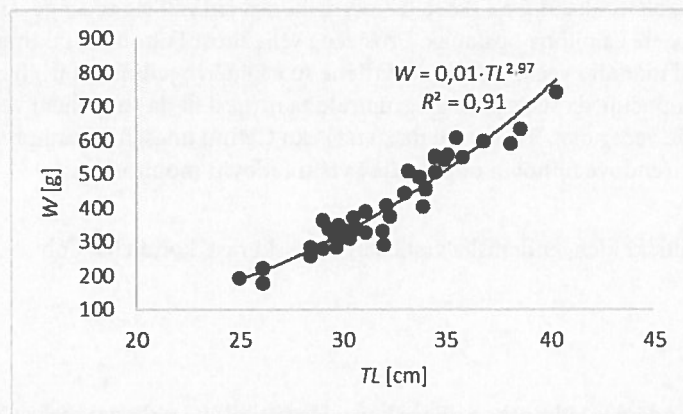
Dužinsko-maseni odnosi analizirani su pomoću jednadžbe za dužinsko-masene odnose (Ricker, 1975.):

$$W = a \cdot L^b$$

Ukoliko je $b = 3$ ribe dobivaju podjednako na masi i dužini, i tada govorimo o izometrijskom rastu, pri $b > 3$ ribe napreduju više u masi, a pri $b < 3$ u dužinu, i tada govorimo o pozitivnom, odnosno, negativnom alometrijskom rastu. Ljuske su uzimane s bočne strane tijela ispod osnove leđne peraje te pohranjene u papirnate vrećice na kojima je napisan redni broj pod kojim je riba vođena. Starost riba određena je identifikacijom anula na ljuskama pomoću digitalnog mikroskopa "Dino-Lite" tipa AM-413T (Murphy i Willis, 1996.).

Rezultati

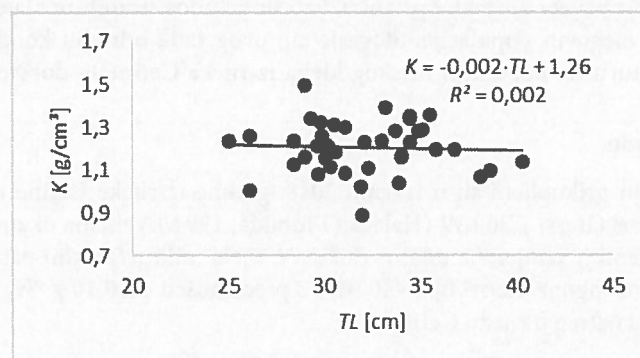
Ukupno je prikupljena i analizirana 41 jedinka ilirskog klena. Minimalna, maksimalna i prosječna vrijednost totalne dužine iznosila je redom 25,00 cm, 40,30 cm i 30,02 cm, dok je minimalna, maksimalna i prosječna vrijednost mase iznosila 179,00 g, 745,00 g i 408,27 g. Temeljem dobivenih dužinsko-masениh odnosa vidljiv je nešto brži prirast u dužinu nego u masu ($b=2,97$) (Slika 1).



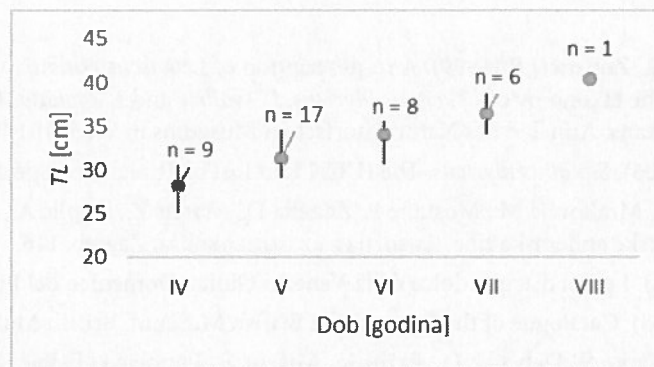
Slika 1. Dužinsko-maseni odnosi ilirskog klena *Squalius illyricus*

Minimalna, maksimalna i prosječna vrijednost kondicijskog faktora ribe iznosila je redom 0,89 g/cm³, 1,50 g/cm³ i 1,21 g/cm³, dok je linearnom regresijom dobivena gotovo konstantna vrijednost kondicijskog faktora s obzirom na totalnu dužinu ribe (Slika 2).

Dob jedinki ilirskog klena ovog istraživanja kreće se u rasponu od 4+ do 8+. Za dobne skupine IV, V, VI, VII i VIII bilo je redom 9, 17, 8, 6 i 1 primjeraka ribe. Prosječne vrijednosti totalnih dužina s obzirom na dob iznosile su od 28,20 cm za dob IV do 40,30 cm za dob VIII (Slika 3).



Slika 2. Odnos između Fultonovog faktora kondicije (K) i totalne dužine (TL) ilirskih klenova *Squalius illyricus*



Slika 3. Broj jedinki (n), minimalna, maksimalna i srednja totalna dužina (TL) u ovisnosti o dobi za ilirskog klena *Squalius illyricus*

Rasprava

Analizom dužinsko-masених odnosa ilirskih klenova ulovljenih u razdoblju 1974. i 1975. godine u rijeci Cetini dobiven je negativan alometrijski rast s prosječnom vrijednošću parametra $b = 2,40$ (Popović i Habeković, 1981.). Slično je za ulov u razdoblju 1985. i 1986. godine (Habeković i sur., 1994.) dobiven negativan alometrijski rast s prosječnom vrijednošću parametra $b = 2,90$ (Treer i sur., 2008.). Ovim istraživanjem je dobivena nešto veća b vrijednost ($b = 2,97$), što ukazuje na lagani alometrijski odnosno skoro izometrijski rast (Slika 1). Vrijeme mrijesta ilirskog klena je od početka svibnja do kraja lipnja (Mrakovčić i sur., 2006.) te dobiveni rezultat ukazuje i na mogućnost da se istraživane jedinke nisu izmrijestile (Leunda i sur., 2006.). Primjerci ilirskih klenova iz Cetine ulovljeni 1975. godine (Habeković i sur., 1975.) pokazali su prosječnu vrijednost Fultonova faktora kondicije od 1,14 (Prpa i sur., 2007.), a primjerci iz Krke ulovljeni 1988. godine (Mrakovčić i sur., 1988.) od 1,22 (Prpa i sur., 2007.). Habeković i sur. (1975.) su obuhvatili jedinke za četiri godišnja doba, kao i veći broj primjeraka nego u ovom istraživanju, što je vjerojatan razlog nešto veće vrijednosti Fultonovog faktora kondicije u ovom istraživanju. Također ovo istraživanje je obavljeno samo u proljetnom razdoblju neposredno prije mrijesta, pa takve jedinke u pravilu imaju veći kondicijski faktor. Ovaj rezultat ukazuje da je rijeka Cetina još uvijek povoljno stanište za ovu vrstu. Kondicija istraživanih primjeraka s obzirom na totalnu dužinu pokazala je gotovo konstantnu vrijednost, što također pokazuje da se starije jedinke nisu izmrijestile (Treer i sur., 2005.). Vjerojatno je uslijed nedostatka manjih primjeraka ilirskih klenova korelacijski koeficijent iznosio svega 0,002 zbog čega regresijska jednadžba ima malu prediktivnu vrijednost (Murphy i Willis, 1996.) (Slika 2). Dobna struktura ilirskih klenova ulovljenih 1985. godine u Cetini u rasponu je od 0 do VIII (Habeković, 1994.; Popović, 1994.) pri čemu je za dobnu skupinu 3+ ($n=31$) i 6+ ($n=34$) ulovljen najveći broj primjeraka (Habeković, 1994.). Ovim istraživanjem utvrđeno je svega pet dobnih skupina, iako je ulovljen i analiziran relativno reprezentativan broj jedinki (Slika 3). Veličina oka mreže na anodi vjerojatno je bila uzrokom nemogućnosti ulova juvenilnih primjeraka. Moguće je i da su uslijed grupiranja za mrijest ulovljene jedinke starijih dobnih skupina od IV do VIII (Slika 3), premda dob spolnog sazrijevanja ilirskog klena još uvijek nije potpuno poznata (Jakšić, 2018.), te je u tu svrhu potrebno provesti detaljna istraživanja. Stanje populacija ilirskog klena potrebno je i dalje pratiti zbog toga što se radi o gotovo ugroženoj vrsti endemske ribe (Crivelli, 2006.), a posebice stoga što su unesene nove vrste predatora iz dunavskog slijeva koje dodatno mogu ugroziti stabilnost populacija ilirskog klena (Piria, 2018.).

Zaključci

Ilirski klenovi pokazali su skoro izometrijski rast te veću vrijednost faktora kondicije nego u prijašnjim istraživanjima, što ukazuje da je rijeka Cetina još uvijek povoljno stanište za ovu vrstu. U prijašnjim je istraživanjima utvrđeno devet, dok je ovim istraživanjem utvrđeno pet starijih dobnih skupina, vjerojatno uslijed formiranja jata za mrijest. Osim toga, moguće je da su b vrijednost i faktor kondicije K nešto veći uslijed porasta mase gonada. Potrebno je i dalje pratiti stanje populacija ove endemske ribe zbog različitih ugroza koje prijete njezinom opstanku.

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Age and growth of the Illyrian chub *Squalius illyricus* from the river Cetina

Abstract

In Croatia, the Illyrian chub *Squalius illyricus* is endemic to the Adriatic Basin and inhabits rivers Cetina and Krka. In the last 20 years, research on this species has not been made, and due to the small area of their habitat, it is important to monitor the state of the population. For the purpose of this research, 41 individuals from the Cetina river were collected in April 2018 and their allometric growth, condition and age were presented. The results indicate almost isometric growth of individuals, indicating that the specified locations are favorable for their survival. The mean value of Fulton's condition factor is 1.21 and is stable for smaller and larger individuals. Only the older individuals from the age group IV to VIII were identified, suggesting that the individuals were grouped for spawning or that larger individuals were hunted due to the use of a larger mesh network. Because foreign predators have been introduced into the river Cetina, it is necessary to carefully monitor trends of their populations and to perform regular monitoring.

Key words: Illyrian chub, endemic species, allometric growth, condition, age

Distribution and population structure of the Unionidae family in the Kupa River in Karlovac County

Juraj PETRAVIĆ¹, Marin JARNJAK¹, Martina ANDRAŠIĆ², Krešimir KURI¹, Goran JAKŠIĆ¹, Helena JAJČEVIĆ³, Matija DERGEZ⁴, Jasna LAJTNER⁵

¹JU AQUATIKA- freshwater aquarium Karlovac, Branka Čavlovića Čavleka 1A, 47000 Karlovac, Croatia (e-mail: jpetravic@aquariumkarlovac.com)

²Ministry of agriculture, Ulica grada Vukovara 78, 10000 Zagreb, Croatia

³Technical high school, Ljudevita Jonkeja 2a, 47000 Karlovac, Croatia

⁴PP Orahovica d.o.o., Stjepana Mlakara 5, Croatia

⁵University of Zagreb, Faculty of Science, Rooseveltov trg 6, 10000 Zagreb, Croatia

Abstract

Distribution and population structure of Bivalvia from the Unionidae family in the Kupa River course in Karlovac County was analysed from April to October 2018. At nine different locations, six species from four genera of this family were found. The dominant species is *Unio crassus* which takes up 32.5%, while the least represented one is *Pseudanodonta complanata* with 4.0%. During this research, the invasive species *Sinanodonta woodiana* was found in four locations. The objective of this paper is to determine the number of species from the Unionidae family and the incidence of every species within the population, and their distribution in the Kupa river in Karlovac County. This is the first research aimed at the distribution and population structure of the Unionidae family in the river Kupa in Karlovac County.

Key words: Unionidae, *Anodonta anatina*, *Sinanodonta woodiana*, Kupa River, population

Introduction

The Unionidae family in the world includes 674 species of freshwater Bivalvia (Graf and Cummings, 2007), while in Croatia have been recorded eight native species of the Unionidae family: thick shelled river mussel *Unio crassus* (Philipsson, 1788), swollen river mussel *Unio tumidus* (Retzius, 1788), painter's mussel *Unio pictorum* (Linnaeus, 1758), duck mussel *Anodonta anatina* (Linnaeus, 1758), depressed river mussel *Pseudanodonta complanata* (Roosmoosler, 1835) (Beran, 2013), swan mussel *Anodonta cygnea* (Linnaeus, 1758) (Delić, 1991), *Unio mancus* (Lamarck, 1819) and *Anodonta exulcerata* (Porro, 1838) (Froufe et al, 2017), and one non-native species of the Unionidae family, Chinese pond mussel *Sinanodonta woodiana* (Lea, 1834) (Hudina et al., 2009). Some species still do not have binominal nomenclature in Croatian and English, so Latin names are used solely. *U. crassus* is included in the Ordinance on strictly protected species (NN, 144/2013) and according to IUCN it has the status of a globally threatened species. *S. woodiana* has been reported as being invasive species in several Europe countries, in Croatia (Hudina et al., 2009), Italy (Colomba et al., 2013), Spain (Lopez- Soriano et al., 2017).

Fish restocking of the lakes and fish ponds could represents the risk of spreading glochidia from *S. woodiana*. *S. woodiana* was introduced in Poland from Hungary with the stocking material of herbivorous fishes in the mid 1980 (Kraszewski, 2007). Two other non-native Bivalvia, Asian clam (*Corbicula fluminea*) and the Zebra mussel (*Dreissena polymorpha*) has been recorded in Croatian freshwaters (Hudina et al., 2009). Several authors have reported negative impacts of *S. woodiana*, *C. fluminea*, and *D. polymorpha* over native freshwater mussel (Pourovira et al., 2009, Dzierzynska- Bialonczyk et al., 2018, Ferreira-Rodriguez et al. 2018). Pavletić and Matoničkin (1972) analysed the structure of biocenosis of the Korana River and found two species of Bivalvia from the Unionidae

family, while Beran (2013) found six species in the same river from 2009 to 2012. So far, malacological research of the Kupa River was done by Habdija et al. (1995), but it dealt with the distribution of freshwater snails according to the type of substrate and it does not include *Bivalvia*. Papers about other research on *Bivalvia* in the course of the Kupa River in Karlovac County are not available, and the information on the species and population structure of Unionidae is scarce. The objective of this paper is to determine the number of species from the Unionidae family and the incidence of every species within the population with their distribution in the Kupa River in Karlovac County.

Material and methods

Study area

The Kupa River in Karlovac County flows partly along its middle and its lower course, and the length of the course is 120 km, which is 41% of the entire river course. It has ten tributaries, the Korana River in Karlovac being the largest, and it is connected to the Kupa-Kupa canal which is 22 km long, fish ponds Kupa, Crna Mlaka and Pisarovina are situated alongside the canal, as well as lake Šumbar near Rečica and Šljunčara lakes near Mali Erjavec.

Samples of *Bivalvia* from the Unionidae family were collected from the Kupa River in Karlovac County from April to October 2018. The sampling locations were marked according to UTM coordinates and were named after the nearest place: 1) 45°37'59"N, 15°20'15"E, - Donji Bukovac Žakanjski, 2) 45°36'51"N, 15°28'45"E - HE Ozalj, 3) 45°37'0"2N, 15°29'16"E - Zajačko selo, 4) 45°31'38"N, 15°31'41"E - Brodarci, 5) 45°29'10"N, 15°35'51"E - Husje, 6) 45°28'46"N, 15°41'18"E - Donja Rečica, 7) 45°29'46"N, 15°40'18"E - Slaćanini, 8) 45°30'54"N, 15°44'19"E - Koritinja, 9) 45°31'38"N, 15°52'38"E - Mrvci.



Figure 1. Map of the Kupa River with locations under study

The samples were collected by hand, through the method of scuba diving to the maximum depth of six metres, exploring the bottom, the sediment and aquatic vegetation. At each location the samples were collected from three different habitats with a joint surface area of approximately 30m², the transect being 100 metres long. After collection of the molluscs, the following parameters were recorded: length, height, width (with 0.1 mm accuracy), and living, wet weight (with 1 g accuracy). The species were determined according to shape, the colour of the shell, the length/height ratio, the length/width ratio, the position of the umbo and the shape of the teeth. The following materials and keys were used for the determination: Pflieger (1998) and Killeen et al. (2004), digital gram scale FA-6405, sliding calliper BGJ Technic, and a Mares quad air depth gauge model. After the determination, all individuals were counted within species according to locations. The entire sample was counted and the population density of each species was calculated within the entire sample according to locations, as well as the population density of each species compared with the entire sample of the whole part of the Kupa River which was researched. All the individuals were sampled *in situ*, and returned to where they were taken from after sampling, except the invasive *S. woodiana*, which were removed from the water due its invasiveness. In this paper empty shells were not measured, only living individuals were analysed.

Results and discussion

In total, 619 individuals were collected from nine locations on the Kupa River, from Donji Bukovac Žakanjski to Mrvci. Six species from four genera of the Unionidae family were identified. The most numerous species is *U. crassus* with 201 individuals, followed by *A. anatina* with 179 individuals, *U. tumidus* with 122 individuals, *S. woodiana* with 53 individuals, *U. pictorum* with 39 individuals, and the least numerous is *P. complanata* with 25 individuals

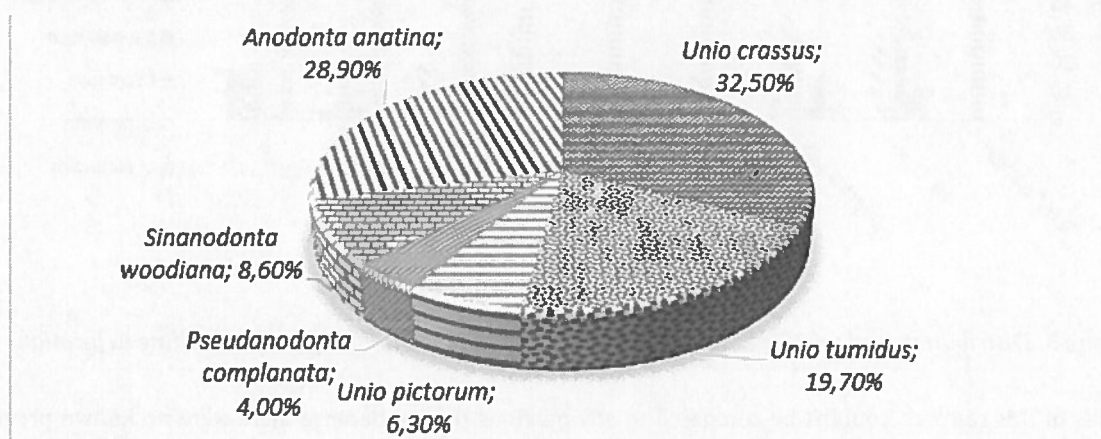


Figure 2. Relative abundance of each species of the Unionidae family in the Kupa River in Karlovac County

The protected *U. crassus* was found in all locations, in great abundance (Chart 1.). *U. crassus* is the most numerous near Koritinja. Upstream from the Hydroelectric power plant Ozalj at D.B. Žakanjski, the smallest biodiversity of Unionidae family was found, only *U. crassus* species. At the same location, the largest share of this population structure (77%) belongs to juvenile individuals weighing less than 10 g, with the average weight of 6.33 g and the average shell length of 3.66 cm. The juvenile individuals were collected along the river bank from depths up to one metre. *S. woodiana* is the dominant species at the Hydroelectric power plant Ozalj location with 42 % and was not found north-west of the Hydroelectric power plant. At three out of four locations where *S. woodiana* was found, all other native species from the Unionidae family were found as well, the most numerous being *A. anatina* and *U. tumidus*. At Hrnetić location were found *U. crassus*, *U. tumidus*, *U. pictorum*, only species from the *Unio* genus. *U. tumidus* is the dominant species at Zajačko selo location (Figure 3), only adult individuals were found at the same location, with the average shell length of 8.02 cm. *P. complanata* was found in five locations in least abundance. The most numerous sample of *P. complanata*, consisting of ten individuals, was found at Zajačko selo location, at the muddy river bottom in thick vegetation at the depth of two metres. According to the type of the substrate, it was noted that *U. crassus* and *U. pictorum* prefer gravel bottoms of small and medium grain size, *S. woodiana*, *P. complanata* and *U. tumidus* are more numerous at muddy bottoms, while *A. anatina* was found equally on muddy and mixed substrates. According to

the velocity of the river course, *U. crassus* was found equally in faster and slower sections, while the other species of Unionidae preferred slower sections of the Kupa River. *A. cygnea* was not found in investigated part of the Kupa River.

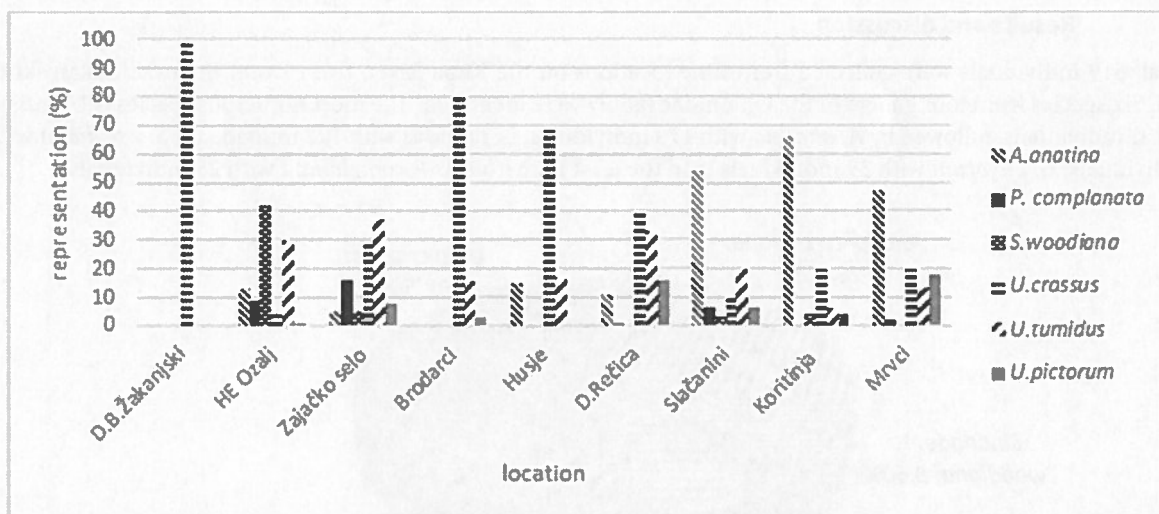


Figure 3. Distribution and relative abundance of each species of Unionidae family according to location

The results of this research couldn't be compared to any previous results, because there were no known previous malacological researches of the Kupa River including Bivalvia. Beran (2013) researched the Korana River and found the presence of *U. crassus*, *U. tumidus*, *U. pictorum*, *A. anatina*, *P. complanata* and *S. woodiana*, the two most common species being *U. crassus* and *A. anatina*, while *A. cygnea* was not found. These results are in accordance with the results from this paper. Pavletić and Matoničkin (1972) recorded two species of Bivalvia from the Unionidae family in their research of the Korana River: *U. crassus* and *A. cygnea*. The authors probably confused *A. anatina* with *A. cygnea*, but it not possible to exclude the occurrence of *A. cygnea* especially in the lower stretch of the river (Beran, 2013). Even though this research did not find *A. cygnea*, it is possible that *A. cygnea* is present in the lower flow of the Kupa River. In order to confirm this thesis, further research needs to be done in the rest of the river. Comparing the results of the distribution of species from the Unionidae family with the results of Korana River researching (Beran, 2013), *U. tumidus*, *U. pictorum*, and *S. woodiana* are more distributed in the Kupa River. In the Korana River, out of 13 researched locations, Beran (2013) found *U. pictorum* in two locations, *U. tumidus* and *S. woodiana* in just one location. The least represented species in present study and Beran (2013) is *P. Complanata*, but there is a difference in the distribution and the abundance. *P. complanata* has a greater abundance and a wider distribution in the Kupa River. Beran (2013) found only one *P. complanata* individual. In comparison with previous research (Lajtner and Crnačan, 2011), distribution of *S. woodiana* has spread further to the west in Croatia. Although it was found in only four locations during this research, *S. woodiana* is the dominant species at the Hydroelectric power plant Ozalj location. Negative influence on the biomass and replacing *A. cygnea* by *S. woodiana* was confirmed by the results of the research of Lake Balaton in Hungary (Benko- Kiss et al., 2013). Old empty shells were found at several locations, belonging to species of the Unionidae family that were not found alive at the same locations. Supposing the empty shells were brought there by water through the regulation of the flow regime of the Hydroelectric power plant Ozalj, empty shells were not measured. This is the first research aimed at the distribution and population structure of the Unionidae family in the river Kupa in Karlovac County.

Conclusions

Strictly protected *U. crassus* was the dominant species in the research and it was found in all of the locations included in this research. *S. woodiana* was recorded in the research but was not found north-west of the hydroelectric power plant Ozalj, therefore the power plant could represent an anthropological barrier for the bivalve species to spread upstream in this part of the Kupa River. In the future, *S. woodiana* could have a negative influence on the biomass of indigenous species of Bivalvia from the Unionidae family in the Kupa River. In order to confirm this thesis, further research into the negative influences of *S. woodiana* on indigenous species of Bivalvia is needed, as well as future research which will include the distribution and population density of Bivalvia from the Unionidae family in whole Kupa River.

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