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Current status and length–weight relation of the European mudminnow, *Umbra krameri* (Actinopterygii: Esociformes: Umbridae), from Jieț River, Dolj County, southwestern Romania

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Abstract

The habitat of the European mudminnow, *Umbra krameri* Walbaum, 1792, is continuously decreasing due to human intervention. The species has a "vulnerable" status according to the IUCN Red List. Thus, new information about the species is needed for conservation efforts. Minnow traps were used for capturing *Umbra krameri* and other small fishes in the Jieț River, Dolj County, southwestern Romania. Captured specimens of *U. krameri* were measured and weighed. Length–weight relations and relative condition factor were determined for the captured *U. krameri* specimens. A total of 94 fishes were captured using the minnow traps. They represented 7 species: European bitterling, *Rhodeus amarus* (Bloch, 1782), roach, *Rutilus rutilus* (Linnaeus, 1758), rudd, *Scardinius erythrophthalmus* (Linnaeus, 1758), Danubian spined loach, *Cobitis elongatoides* Băcescu et Mayer, 1969, weatherfish, *Misgurnus fossilis* (Linnaeus, 1758), tubenose goby, *Proterorhinus marmoratus* (Pallas, 1814), and *U. krameri*. The specimens of *Umbra krameri* represented 44% (41 specimens) of the total catch. The wet body weight (BW) of *U. krameri* ranged from 0.8 to 5.1 g, having a mean value of 2.102 g. The mean total length (TL) was 5.782 cm, ranging from 4.59 to 7.87 cm. According to the length–weight relation (LWR), the growth type of *U. krameri* was positive allometric based on the determined equation: $BW = 0.0068TL^{3.277}$. The mean value determined for the relative condition factor (K_n) was 1.0056486. The growth condition of 46% of the specimens was poor ($K_n < 1$; $n = 19$), while the other 54% were in good condition ($K_n \geq 1$; $n = 22$). The presently reported study provides information about the presence of *U. krameri* in the Jieț River (Dolj County, Romania), a location where the species has not been previously reported. The LWRs show an allometric positive growth. The relative condition factor shows that 46% of the specimens had poor growth, while the rest were in good condition. Minnow traps were an efficient tool for small fish capture.

Keywords

allometry, condition factor, Danube basin, vulnerable species, freshwater fish

Introduction

The European mudminnow, *Umbra krameri* Walbaum, 1792, is a small, stagnophilic fish from the order Esociformes, family Umbridae, being the only native umbrid of Europe. The species has the status "vulnerable" according to the IUCN Red List, with a decreasing population trend (IUCN 2023). The fish usually reaches 5 cm, with a maximum recorded length of 17 cm (Povž 1995). *Umbra krameri* has a laterally compressed head and caudal peduncle, a convex dorsal profile, rounded pectoral fins, and large cycloid scales (Bănărescu 1964). It has 33–35 scales on the mid-lateral line and presents dark spots on the body and head (Kottelat and Freyhof 2007). It has a distinguishable light color line on the flank (Bănărescu 1964).

Umbra krameri is mainly distributed in the Danube River catchment, but also in the Dniester catchment (Froese and Pauly 2022). Its presence was reported in Neusiedler and Balaton lakes (Lelek 1987; Bíró and Paulovits 1995), in the rivers Morava, Pek, Tisza, Er, Ier, Sava, Drava, and Mura (Ristić 1977; Wilhelm 1984, 1987, 2003; Mrakovčić and Kerovec 1990; Povž 1990; Delić et al. 1997; Sekulić et al. 1998; Mrakovčić et al. 2006; Govedič 2010; Petronić et al. 2010; Zanella unpublished*) and in Sibnica Canal (Cakić and Hristić 1987), and other places. The European mudminnow is mainly present in Austria, Slovakia, Hungary, Slovenia, Croatia, Serbia, Romania, Moldova, and Ukraine (Pekárik et al. 2014). Other authors mention the presence of the species in Bosnia, Bulgaria, and the Czech Republic (Bănărescu 1994).

In Romania, the fish is present in some ponds and marshes of Satu Mare, Bihor, Ilfov, Giurgiu, and Călărași counties, in the Danube, its delta, and the Prut River (Oțel 2007; Wilhelm and Ardelean 2009; Telcean et al. 2014). An unclear situation exists in some regions where the fish has been found only sporadically (Imecs and Nagy 2013; Năstase and Oțel 2016). It was also reported in Banat and Oltenia regions, southwestern Romania (Covaciu-Marcov et al. 2018).

The spawning of *U. krameri* usually occurs in March–April, when the temperature of the water ranges between 12 and 16°C. The female initiates the spawning, and two or more males participate. The fish needs a sandy substrate for spawning. The number of eggs is low, with peaks of 2700–2800 eggs reported, but usually between 200 and 1600 eggs (Müller et al. 2015). Not all eggs are laid, some are being resorbed. However, they have a higher chance of survival, as the female is a protective parent, chasing predators and removing nonviable eggs. At a temperature of 13°C, the eggs need 10 to 13 days to hatch (Müller et al. 2011).

Umbra krameri is highly dependent on some habitat conditions. It needs stagnant bodies of water or a very low water flow, low levels of turbidity, and dense macrophytes, preferring marshes, canals, and ponds (Wiesinger 1956; Bănărescu 1964; Wanzenböck 1995). The fish is well adapted to waters with low levels of dissolved oxygen. Its swim bladder is highly vascularized, enabling the fish to use atmospheric air as an oxygen source (Wilhelm 1998). One of the main reasons for the population decline is the loss of habitat due to anthropogenic activities (Keresztessy 1995). For example, Janković (1995) reported the species in the Negotinsko Blato floodplain, which later disappeared after infrastructure development in the area that destroyed its habitat. Bănărescu (1964) reported the species in Iasi County, Romania, but recent samplings in the area did not mention the species. Because of its specific demands for habitat conditions, The Habitat Directive of the European Union (92/43/EEC) includes the species in Annex II (species whose conservation requires the designation of Special Conservation Areas). Other authors also suggest the need for protective measures regarding this species (Takács et al. 2015; Marić et al. 2019), some even managing successful reproduction in captivity (Müller et al. 2015).

It is difficult to determine the exact area of distribution of *U. krameri*, as the species is losing habitat at a fast pace, being forced sometimes to migrate to new habitats. Other reasons for inconsistencies in reporting are the low number of studies regarding this species in areas where it might be present and the difficulty in capturing it using electrofishing when the fish remains in the mud or entangles itself in vegetation. Invasive species also pose a problem for the conservation of *U. krameri* populations. Müller et al. (2015) note that there are 3 species that threaten the *U. krameri* population: the Chinese sleeper, *Perccottus glenii* Dybowski, 1877, the eastern mudminnow, *Umbra pygmaea* (DeKay, 1842), and the Prussian carp, *Carassius gibelio* (Bloch, 1782), all three being considered invasive species in native areas of the European mudminnow.

Considering all the aforementioned aspects, this study aims to provide information on the presence, length–weight relation (LWR), and condition factor of the *U. krameri* population from one of its few existing habitats, namely the Jieț River, Dolj County, Romania. The information can supplement existing data regarding the species and may be used in conservation efforts.

Materials and methods

The Jieț River is a former tributary of the Jiu River, flowing from north to south and discharging in the Danube at Bechet. The general landscape is characterized by forest steppe and floodplains, being greatly affected by drought (Vijulie et al. 2017). The meandered course of the entire river is bordered by agricultural land. Fish sampling was performed from 26 to 27 March 2021 on the Jieț River, near the localities Tâmburești (44.0277457, 23.9221236), Murta (43.9913192, 23.9317484), and Sadova (43.9125837, 23.9133019), Dolj County (Figs. 1–2).

* Zanella D (1997) Rasprostranjenost i zaštita vrste Umbra krameri Walbaum, Pisces. BSc thesis, University of Zagreb, Zagreb, Croatia.

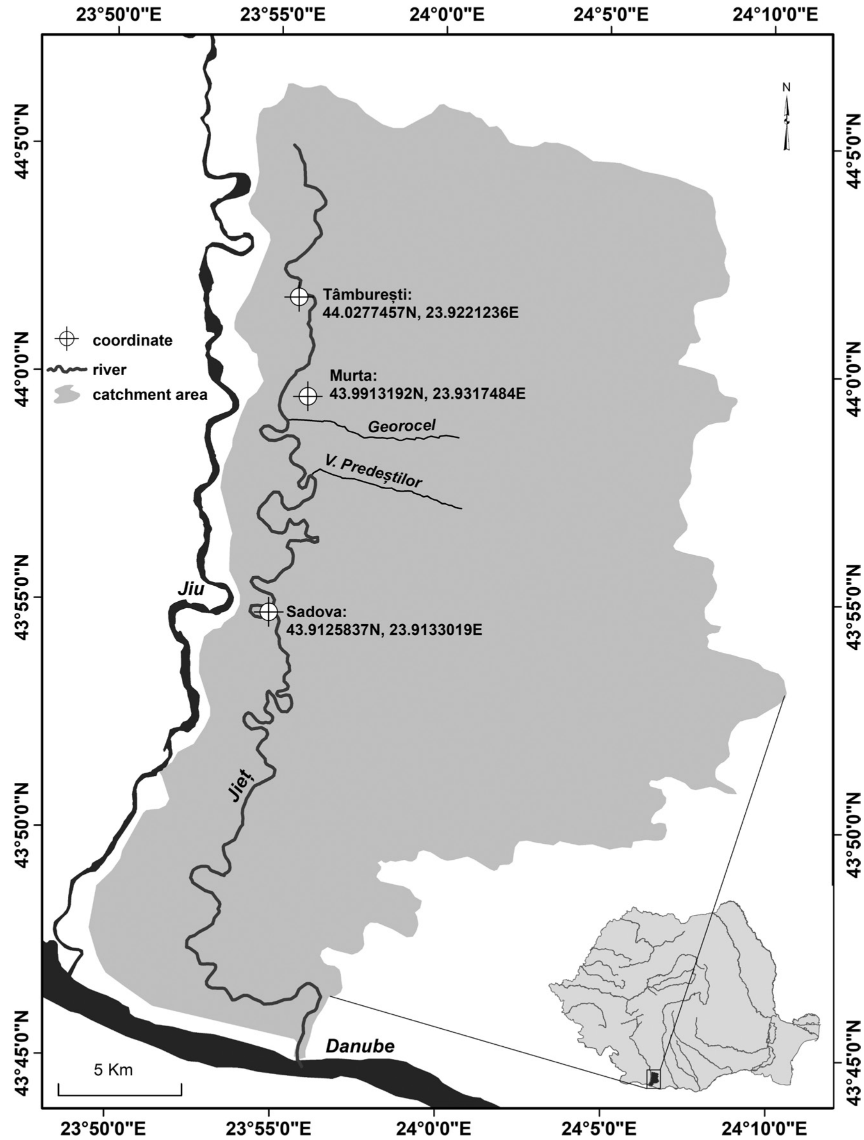

Figure 1. Location of sampling points on the Jieț River, Romania.

Figure 2. Natural landscape and habitat of *Umbra krameri* (Tâmburești, Murta and Sadova localities, Dolj County, Romania). Photo: M. Moraru, 2021.

Sampling sites were chosen for investigation based on local information and specialty literature (Bănărescu et al. 1995; Covaciu-Marcov et al. 2018).

Fish sampling was performed using 15 baitfish/minnow traps (umbrella type), a highly effective fishing gear, especially for small fish species (Portt et al. 2006; Arifianto et al. 2021). To increase the efficiency of the traps, 100 g of mixed sinking carp feed and trout pelleted feed (3 and 6 mm, respectively) were introduced into the trap's bait pocket. Fishing time for each trap was 12 h (from 20:00 to 08:00 h). Water temperature varied from 12.3 to 11.9°C. All the sampled specimens were released into their natural habitat after the body measurements were performed.

Body measurements, such as total length (TL), standard length (SL), maximum body height (*H*) , minimum body height (*h*), head length (HL), and eye diameter (ED) were performed using a caliper. The fish's wet body weight (BW) was determined using an Adam Dune DCT 2000 portable digital scale (to the nearest 0.1 g). In addition to TL and BW, which were used to determine LWR, the other measurements were determined for exploratory purposes and to supplement the specific literature devoted to *Umbra krameri*. We opted for a small number of performed body measurements for each individual based on unfavorable field conditions and to keep a minimal exposure of specimens to atmospheric air, as the species has a decreasing population trend and its conservation status is vulnerable (VU vulnerable according to IUCN). The TL was also used for age estimation, according to previous studies on the species (Wanzenböck 1995; Povž 1995; Wilhelm 2003). Descriptive statistics consisting of mean values, maximum values, minimum values, range, standard deviation, standard error of the mean, coefficient of variation, and LWR were determined in Microsoft Excel for Windows, MS Excel 2016, version 16.0.4266.1001.

The LWR was determined by applying the formula

$$\mathrm{BW} = a\mathrm{TL}^{b}$$

where *a* and *b* are the coefficients of the regression between BW and TL (Le Cren 1951). The values of coefficients *a* and *b* were determined by the least-square linear regression from the log-transformed values of TL and BW, using the formula

$$\mathrm{BW} = \log a + b \log \mathrm{TL}$$

(Morey et al. 2003; Sangun et al. 2007; Yosuva et al. 2018). To determine the type of growth for the sampled *U. krameri* specimens, values of *b* exponent were analyzed as follows: positive allometric growth, if $b > 3$; negative allometric growth, if $b < 3$; and isometric growth, if $b = 3$ (Froese 2006). Confidence intervals (CI) at 95% were determined to establish if the *b* value obtained from the linear regression was significantly different from the isometric value ($b = 3$). In addition, the *t*-test was used to determine if the obtained *b* value was significantly different from the isometric value and establish the growth type. The null hypothesis of isometric growth (H_0: $b = 3$) was also tested by *t*-test for $\alpha = 0.05$ (Mehanna and Farouk 2021). The relative condition factor (K_n) of each individual was determined by the following equation –

$$K_n = W_o W_e^{-1}$$

where W_o is the observed weight and W_e is the expected weight determined from the LWR (Jisr et al. 2018). The fish condition can be evaluated as follows: $K_n \geq 1$, when the fish growth condition is good, and $K_n < 1$, when the fish growth condition is poor (Le Cren 1951). Body measurements, calculations, and regression were performed on the combined sexes.

Results

A total of 94 fishes were captured using the minnow traps. They represented 7 species: European bitterling, *Rhodeus amarus* (Bloch, 1782), roach, *Rutilus rutilus* (Linnaeus, 1758), rudd, *Scardinius erythrophthalmus* (Linnaeus, 1758), Danubian spined loach, *Cobitis elongatoides* Băcescu et Mayer, 1969, weatherfish, *Misgurnus fossilis* (Linnaeus, 1758), tubenose goby, *Proterorhinus marmoratus* (Pallas, 1814), and *U. krameri* (Table 1).

The BW of the studied specimens of *U. krameri* ranged from 0.8 to 5.1 g, having a mean value of 2.102 g. The mean TL was 5.782 cm, ranging from 4.59 to 7.87 cm. The mean SL was 4.852 cm, ranging from 3.72 to 6.65 cm. The determined mean value of *H* was 1.245 cm, while the mean *h* was 0.6688 cm. HL ranged from 0.98 to 1.96 cm, with a determined mean value of 1.322 cm. ED ranged from 0.18 to 0.4 cm, and the mean value was 0.2805 cm. In terms of body measurement variation, BW recorded the highest coefficient (49.83%), while the lowest variation was observed in the case of TL (14.29%) (Table 2).

The growth type of *U. krameri* according to our determinations of LWR was allometric positive ($b = 3.227$), rejecting the null hypothesis (H_0: $b = 3$) (Table 3). The determined LWR equation for the studied species is $\mathrm{BW} = 0.0068\mathrm{TL}^{3.277}$.

The mean value determined for the relative condition factor (K_n) was 1.0056486, showing a general good condition ($K_n \geq 1$) (Fig. 3). When analyzing the minimum ($K_n = 0.788$), maximum ($K_n = 1.228$) and standard deviation (0.1425) values of K_n, it can be observed that the data is not grouped around the mean value. To provide a more accurate trend of the population, the data was divided into two categories as follows: group $K_n \geq 1$, and group $K_n < 1$. It was noted that 46% of the specimens were in a poor growth condition (group $K_n < 1$; $n = 19$) and 54% of the specimens were in good condition (group $K_n \geq 1$; $n = 22$).

Table 1. Fish species captured in the Jieț River using fish traps.

Order	Family	Species	No. of specimens
Cypriniformes	Acheilognathidae	*Rhodeus amarus* (Bloch, 1782)	2
	Leuciscidae	*Rutilus rutilus* (Linnaeus, 1758)	6
		Scardinius erythrophthalmus (Linnaeus, 1758)	1
	Cobitidae	*Cobitis elongatoides* Băcescu et Mayer, 1969	12
		Misgurnus fossilis (Linnaeus, 1758)	11
Esociformes	Umbridae	*Umbra krameri* Walbaum, 1792	41
Gobiiformes	Gobiidae	*Proterorhinus marmoratus* (Pallas, 1814)	21

Table 2. Descriptive statistics for the determined body measurements of *Umbra krameri* from the Jieț River, Romania.

Character	Descriptive statistics						
	n	Min	Max	Range	Mean ± SD	SEM	CV%
BW [g]	41	0.8	5.1	4.3	2.102 ± 1.0480	0.1636	49.83%
TL [cm]	41	4.59	7.87	3.28	5.782 ± 0.8264	0.1291	14.29%
SL [cm]	41	3.72	6.65	2.93	4.852 ± 0.7021	0.1096	14.47%
H [cm]	41	0.88	1.76	0.88	1.245 ± 0.2315	0.03616	18.59%
h [cm]	41	0.49	0.94	0.45	0.6688 ± 0.1189	0.01857	17.78%
HL [cm]	41	0.98	1.96	0.98	1.322 ± 0.2168	0.03386	16.39%
ED [cm]	41	0.18	0.4	0.22	0.2805 ± 0.0471	0.007358	16.80%

n = number of specimens, Min = minimum, Max = maximum, SD = standard deviation, SEM = standard error of mean, CV% = coefficient of variation; BW = wet body weight, TL = total length, SL = standard length, *H* = maximum height, *h* = minimum height, HL = head length, ED = eye diameter.

Table 3. The length–weight relation (LWR) determined for *Umbra krameri* from the Jieț River, Romania; equation $BW = 0.0068TL^{3.277}$.

LWR parameter					Growth type
a	*b*	*a* CI95%	*b* CI95%	R^2	
0.0068	3.227	0.0040–0.0115	2.876–3.567	0.9011	*b* > 3 (allometric positive)

a = intercept, *b* = the slope of the LWR regression, CI = confidence interval, R^2 = coefficient of determination of length–weight relation, BW = wet body weight, TL = total length.

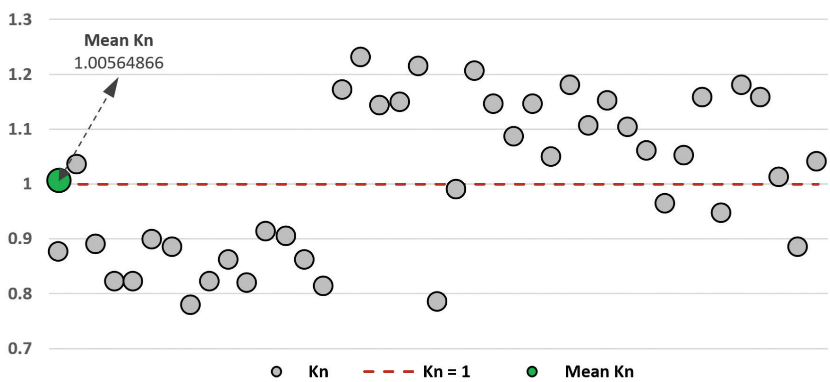

Figure 3. The relative condition factor: grey marker-individual values; green marker-mean value of the sample; red dotted line represents $K_n = 1$.

Discussion

The specimens of *Umbra krameri* represented 44% (41 specimens) of the total catch. According to the determinations of Wanzenböck (1995), Povž (1995), and Wilhelm (2003), the mean TL of *U. krameri* in different age groups were as follows 48.3 mm (0+ fish), 55.4 mm (1+), 63 mm (2+), 70.4 mm (3+), 82 mm (4+), = 91.5 mm (5+), and 105.5 mm (6+ fish). By comparing the above information to the observations from this study (Table 2), we estimated that the age of analyzed specimens from the Jieț River ranged from 0+ to 3+ years.

The LWR determined in the presently reported study was similar to that of other studies (Sekulić 2013; Bíró and Paulovits 1995; Wilhelm 2003), showing positive allometric growth. Other populations studied by Bíró and Paulovits (1995) and Sehr (2014) showed negative allometric growth. Based on the analyzed similar studies, comparable LWRs were also observed for the other two species of the genus *Umbra*: *Umbra pygmaea* and *Umbra limi* (Kirtland, 1840) (see Dederen et al. 1986; Verreycken et al. 2010; Robinson et al. 2010; Panek and Weis 2012). The LWRs obtained in other studies for members of the genus *Umbra* are presented in Table 4.

Table 4. Length–weight relations of *Umbra* species from analyzed specialty literature and presently reported study.

Species	Country/Area	Equation	*b*	*n*	Growth type	Sex	Reference
Umbra krameri	Serbia	$BW = 0.000001TL^{3.63}$	3.63	21	ALLO+	♀+♂	Sekulić 2013
	Serbia	$BW = 0.000001TL^{3.59}$	3.59	13	ALLO+	♂	Sekulić 2013
	Serbia	$BW = 0.0000005TL^{3.68}$	3.68	8	ALLO+	♀	Sekulić 2013
	Bosnia and Herzegovina	$BW = 0.000002TL^{3.46}$	3.46	32	ALLO+	♀+♂	Sekulić 2013
	Bosnia and Herzegovina	$BW = 0.000002TL^{3.44}$	3.44	11	ALLO+	♂	Sekulić 2013
	Bosnia and Herzegovina	$BW = 0.000004TL^{3.25}$	3.25	16	ALLO+	♀	Sekulić 2013
	Hungary	$BW = 0.000003TL^{3.5189}$	3.5189	479	ALLO+	♀+♂	Bíró and Paulovits 1995
	Hungary	$BW = 0.00076TL^{2.1771}$	2.1771	133	ALLO–	♀+♂	Bíró and Paulovits 1995
	Hungary	$BW = 0.00001TL^{3.1904}$	3.1904	133	ALLO+	♀+♂	Bíró and Paulovits 1995
	Austria	$BW = 0.00003TL^{2.7349}$	2.7349	261	ALLO–	♀+♂	Sehr 2014
	Romania	$BW = 0.0023TL^{3.3429}$	3.3429	252	ALLO+	♀+♂	Wilhelm 2003
	Romania	$BW = 0.0068TL^{3.277}$	3.277	41	ALLO+	♀+♂	Presently reported study
Umbra pygmaea	Flanders Belgium	$BW = 0.0075TL^{3.243}$	3.243	803	ALLO+	♀+♂	Verreycken et al. 2010
	North America	$BW = 0.00001TL^{3.182}$	3.182	97	ALLO+	♂	Panek and Weiss 2012
	North America	$BW = 0.00001TL^{3.032}$	3.032	84	ALLO+	♀	Panek and Weiss 2012
	Netherlands	$BW = 0.0034TL^{3.55}$	3.55	547	ALLO+	♀+♂	Dederen et al. 1986
Umbra limi	North America	$BW = 0.0069TL^{3.175}$	3.175	133	ALLO+	♀+♂	Robinson et al., 2010

b = the slope of the LWR regression, *n* = number of analyzed specimens; BW = wet body weight, TL = total length; ALLO+ = allometric positive growth; ALLO– = allometric negative growth.

The positive allometric growth determined for *U. krameri* (both sexes combined) from the Jieț River might have been affected by the sampling period (March 2021), which coincides with the spawning period of the species. In general, during the spawning period, fish of both sexes cease to feed and their sexual dimorphism becomes more pronounced. In terms of sexual dimorphism, Wanzenböck (1995) mentioned that males appear "more slender" than females and sexual differentiation should be viewed with caution. This may explain the determined differences in K_n.

According to Dederen et al. (1986), *U. pygmaea* and *U. limi* may play the role of top predators in their natural ecosystems, an aspect that may be observed in the presently reported case with *U. krameri*, especially as common predators as the northern pike *Esox lucius* and perch *Perca fluviatilis* were absent. Another similarity with the study of Dederen et al. (1986) is in terms of species structure, the presence of *R. rutilus* and *S. erythrophthalmus* being noticed in both instances.

Conclusion

The presently reported study provides basic information on the presence of *Umbra krameri* in the Jieț River (Dolj County, Romania) as well as the LWR and relative condition factor of the sampled specimens. The results from this study may prove useful to conservation programs needed for *U. krameri* and its habitat. In terms of fish sampling, the minnow traps were an efficient tool for small fish capture.

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