

Some biological data on cactus roach, *Rutilus virgo* (Heckel), in rivers of the Transcarpathian region of Ukraine

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Abstract. The occurrence of *Rutilus virgo* (Heckel) has been confirmed in the Transcarpathian region of Ukraine, where it was caught in the lower stretches of the Latorica and Borzhava rivers. The comparison of selected morphometric features of *R. rutilus* and *R. virgo* showed that 26 of 40 of them were significantly different and the largest differences were observed for features such as head length, maximum body depth, pectoral fin length, pectoral fin thickness, pelvic fin length, head depth at eye level, maximum head depth, and preorbital length. The comparison of *R. virgo* of two size groups showed a number of changes in fish body proportions during fish growth, where 29 of 38 features were different. Length-weight relationship for mixed sexes was $a = 0.0157$, $b = 3.088$. The fecundity of *R. virgo* depended on age and varied from 6775 eggs (age 4+) to 51535 eggs (age 8+). *R. virgo* inhabiting the rivers of the Transcarpathian region is characterized by relatively rapid growth rate, and the results are within growth rate limits reported in the literature.

Keywords: Tisza River, Latorica River, Borzhava River, morphometric features

Introduction

Species of the genus *Rutilus* (roach) in Ukraine are represented by *R. rutilus* (L.), *R. frisii* (Nordmann), and the introduced *R. kutum* (Kamensky) (Movchan 2011). However, the latter species is considered to be a subspecies of *R. frisii* (Bogutskaya and Naseka 2004). Cactus roach, *Rutilus virgo* (Heckel), is not listed in the fish fauna of Ukraine; however, the possibility of its occurrence here is mentioned by Movchan (2011) with a reference to a quite unreliable, non-scientific book (Turyanin 1982). Information on the occurrence of *R. virgo* in the Transcarpathian region of Ukraine is first presented by Turyanin (1982), who probably copied it from Banarescu (1964), and this reference contains detailed data on the distribution of this species in the Tisza river drainage within Romania, and it includes information that it enters some Tisza river tributaries such as the Tur, Borzhava, Batar, and Siren. However, this book does not contain any documented data on actual catches of *R. virgo*, which are crucial for a first description of this species within the territory of Ukraine. Luhovoy and Kovalchuk (1999-2000) indicated its occurrence in lower stretches of the Latorica and Borzhava rivers as well as in the frontier zones of the Tisza River.

The first reliable mention of the occurrence of *R. virgo* in Ukrainian territory was in the paper by

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Harka (2006), in which are indicated sampling sites of this species in the Tisza River upstream from the village of Vilok (Harka 2006). A catch record of one *R. virgo* specimen in the Tisza River near the village of Petrovo in 2010 was erroneously claimed as the first official record in Ukraine (Dolinskiy et al. 2011); however, this is not mentioned in later publications (Dolinskiy et al. 2012a, Dolinskiy et al. 2012b).

Rutilus virgo is recorded in Slovak rivers near the Ukrainian border (Bodrog, Latorica) (Harka 2006, Koščo et al. 2011), in Hungarian stretches of the Tisza River and its tributaries of Tur, Szamos, and Kraszna, in frontier stretches of the Tisza River from Chop to the village of Salovka, and between Tivadar and Lónya (Györe et al. 1995, Harka et al. 1999, Harka 2006, Györe and Józsa 2010). This species also occurs in other countries of the Danube drainage basin, including Austria, Bosnia and Herzegovina, Bulgaria, Croatia, the Czech Republic, Germany, Italy, Macedonia, Montenegro, Romania, Serbia, and Slovenia (Kottelat and Freyhof 2007, Freyhof and Kottelat 2008). There is little information on the biology of this species and literature

reports refer mainly to its distribution (Povž et al. 1998). The aim of this study is to increase general knowledge about *R. virgo* inhabiting the territory of the Transcarpathian (Zakarpattia) region of Ukraine, including its biological peculiarities, distribution range, and main differences from *R. rutilus* in external morphology.

Material and methods

The data were collected in 2009-2012 from different water bodies across the Transcarpathian region of Ukraine (Fig. 1, Table 1). Fish in the Borzhava River were caught using gill nets (length – 35 m, depth – 1.8 m, stretch mesh size – 30, 36, 40, 45, 50 mm), other fish were caught using angling gears and dip-nets (1 x 1 m, 5 mm mesh). Fish standard length (*SL*) and weight were measured in the field to the nearest 1 cm and 0.1 g using a ruler and electronic scale, respectively. Then the fish caught were preserved in a 4% formaldehyde solution, and their morphometric features were measured later with an



Figure 1. Map of Tisza River drainage in the Tanscarpathian region of Ukraine with locations where *R. virgo* was found.

Table 1

Catch location of fish used for biometric analysis

Species	n	Place of catchment	Date	Coordinates
<i>R. rutilus</i>	4	Stara River (Latorica River tributary) Mukachevo district, Znyatsevo village	16.06.2012	48°29'25"N 22°31'31"E
	14	Slatina canal (Latorica River tributary), Uzhgorod district, Velyki Geivtsi village	9.07.2012	48°30'17"N 22°21'23"E
<i>R. virgo</i>	1	Borzhava River, Beregovo district, Bene village	29-30.12.2011	48°09'48"N 22°46'44"E
	15	Borzhava River, Beregovo district, Bene village	25.11.2011	48°09'48"N 22°46'44"E
	2	Borzhava River, Beregovo district, Kvasovo village	20.10.2011	48°11'33"N 22°46'24"E
	1	Latorica River, Uzhgorod district, Solomonovo village	12-13.06.2011	48°27'24"N 22°10'18"E
	14	Latorica River, Uzhgorod district, near Ukrainian-Slovak border	21-22.07.2012	48°27'3"N 22°10'10"E

electronic caliper to the nearest 0.1 mm. Fish sex was determined by abdominal cavity dissection. Female gonads were removed and weighed with electronic scales to the nearest 0.01 g. Absolute fecundity was determined by the gravimetric method (Bagenal and Braum 1978). Relative fecundity was found as the ratio of total number of eggs to total weight of fish. Age was determined using scales. A part of the collected material (7 specimens) was deposited in the archival collection of the National Museum of Natural History of the National Academy of Sciences of Ukraine.

Measurements and calculations of 40 morphometric and 13 meristic characters were performed. The following abbreviations were used in the tables and text: Features included morphometric measurements: *SL* – standard body length (the measurement from the anterior-most tip of the body to the midlateral posterior edge of the hypural plate); % relatively *SL*: *TL* – total length; *lc* – head length; *H* – maximum body depth, *h* – minimum body depth; *iH* – maximum body width; *ih* – body length at minimum body depth; *aD* – predorsal length; *poD* – postdorsal length; *pP* – prepectoral length; *pV* – prepelvic length; *pA* – preanal length; *PA* – distance between the pectoral and anal fin bases; *PV* – distance between pectoral and pelvic fin bases; *VA* –

distance between pelvic and anal fin bases; *lpc* – length of caudal peduncle; *IC₁* – length of caudal fin upper lobe; *IC₃* – length of lower lobe of caudal fin; *hpc* – depth of caudal peduncle; *lapc* – width of caudal peduncle; *ID* – length of base of dorsal fin; *hD* – dorsal fin maximum depth; *hDf* – dorsal fin minimum depth; *IA* – length of base of anal fin; *hA* – depth of anal fin; *IP* – length of pectoral fin; *lpbs* – length of pectoral fin base; *th.P* – thickness of pectoral fin (Talabishka 2010); *IV* – length of pelvic fin; *IVbs* – length of base of pelvic fin; *V-an* – distance from the beginning of the pelvic fin base to the anal orifice; *an-A* – distance from the anal orifice to the anal fin base; % of head length: *hoI* – head depth at eye level; *hc* – maximum head depth; *lr* – preorbital length (snout length); *O* – horizontal eye diameter; *poO* – postorbital length; *lac* – head width; *io* – interorbital length; *lmx* – upper jaw length; *ina* – distance between the nostrils; and meristic characters: *ll* – total number of scales in the lateral line; *ll. with pores* – number of scales in the lateral line with pores; *ll. without pores* – number of scales in the lateral line without pores; *Du* – number of unbranched rays in the dorsal fin; *Db* – number of branched rays in the dorsal fin; *Au* – number of unbranched rays in the anal fin; *Ab* – number of branched rays in the anal

fin; P – number of rays in the pectoral fin; V – number of rays in the pelvic fin; C – number of rays in the caudal fin; Squ_1 – number of transverse scales between the lateral line and the origin of the dorsal fin; Squ_2 – number of transverse scales between the lateral line and the origin of the anal fin; cir – number of circumpendicular scales. All features except SL were expressed in percent of SL or in percent of lc .

The length-weight relationship was calculated using the equation (Le Cren 1951):

$$W = a \times SL^b$$

where W is the total weight in g, SL is the standard length in cm, a is the intercept, and b is the slope of the regression.

The Fulton condition factor was estimated using the equation (Anderson and Neumann 1996):

$$K = (W \times SL^{-3}) \times 100,000$$

The morphometric measurements and meristic characters of *R. virgo* and *R. rutilus* and morphometric measurements of two size groups of *R. virgo* were compared using the t -test. The t -test was applied to % values. Calculations were performed in MS Excel 2010, while statistical analysis was performed in Statistica 8.0.

Results and discussion

The results confirm that two *Rutilus* species inhabit the Transcarpathian region of Ukraine. *Rutilus rutilus* is quite common and widespread (Movchan and Smirnov 1981), while *R. virgo* seems to have a narrower range (Fig. 1). Local people, mainly the Hungarian minority, clearly identify cactus roach in the frontier zones of the Tisza River and the lower stretches of the Borzhava River as “leánykoncér” (this name is also mentioned by Luhovoy and Kovalchuk (1999-2000)), which is the Hungarian name for this fish, while other people usually confuse this species with ide, *Leuciscus idus* (L.). In the Ukrainian part of the Latorica River, *R. virgo* is sometimes called “Danube roach,” but mostly the two *Rutilus* species are not distinguished and are referred to as “plitka” or

“plotva” or “plotica” (the name for roach in Ukrainian, Russian, and Slovak, respectively). It is noteworthy that the name “plotica” is often used by local people in the Transcarpathian region for spirin, *Alburnoides bipunctatus* (Bloch), and this confuses some recreational fishers.

The comparison of the morphometric features of *R. rutilus* and *R. virgo* showed that 26 of 40 of them were significantly different (Table 2). The greatest differences were observed in features such as head length (lc), maximum body depth (H), length of pectoral fin (lP), thickness of pectoral fin ($th. P$), length of pelvic fin (lV), head depth at eye level (ho), maximum head depth (hc), and preorbital length (lr). The total length (TL) of *R. rutilus* is somewhat greater, which is related to the longer length of the lower lobe of the caudal fin that allows differentiating this species from *R. virgo* in the field; however, since the caudal peduncle is quite susceptible to mechanical damage, this feature differentiation should be used in consideration of this fact. Maximum body depth (H), caudal peduncle base depth (h), maximum body width (iH), and width of caudal peduncle ($lapc$) of *R. virgo* are smaller than those of *R. rutilus*.

The pectoral fins in *R. virgo* are located somewhat closer to the head, while the pelvic fins are a little bit farther away from it in comparison to *R. rutilus*. This location of the pelvic fins influences the pectoventral (PV) and ventroanal (VA) lengths and the distance from the pelvic fin to the anal orifice. The location of the anal fin in both species is exactly the same as is reflected in the preanal (pA) and pectoanal (PA) lengths and the caudal peduncle length, for which no significant differences were detected. *R. rutilus* is characterized by a higher and wider caudal peduncle (hpc and $lapc$), has a relatively larger length of base of dorsal fin (lD) and posterior edge depth (hDf) compared to *R. virgo*; however, the maximum depths of the dorsal fins (hD) of both species are exactly the same. The anal fin (hA) in *R. virgo* is smaller, but the lengths of its base (lA) in the two species are similar. The pectoral and pelvic fins in *R. rutilus* are relatively larger in all features except the length of pectoral fin base ($lpbs$), which are exactly the same in both species. These two species are distinctly different in features that

Table 2Comparison of morphometric measurements of *R. virgo* and *R. rutilus* from the Transcarpathian region of Ukraine

Features	<i>R. virgo</i> (n = 14)		<i>R. rutilus</i> (n = 15)		t	P
	mean ± SE	min-max	mean ± SE	min-max		
SL	83.1 ± 4.29	68.5-118.6	83.4 ± 2.7	65.2-102.4	0.05	0.957
% SL						
<i>TL</i>	126.1 ± 0.79	118.8-130.3	128.3 ± 0.48	125.9-131.7	2.52	0.018
<i>lc</i>	25.4 ± 0.25	23.5-27.0	26.9 ± 0.22	25.4-28.1	4.49	<0.001
<i>H</i>	26.2 ± 0.35	23.9-28.8	30.2 ± 0.38	26.5-32.1	7.66	<0.001
<i>h</i>	9.8 ± 0.1	9.1-10.2	10.4 ± 0.12	9.3-11.1	3.77	0.001
<i>iH</i>	12.9 ± 0.18	11.5-13.7	13.9 ± 0.19	12.5-15.1	3.50	0.002
<i>ih</i>	3.9 ± 0.13	3.1-5.0	5 ± 0.28	3.5-6.7	3.27	0.003
<i>aD</i>	53.6 ± 0.31	50.3-55.1	54.2 ± 0.4	51.6-56.5	1.04	0.309
<i>poD</i>	34.9 ± 0.24	33.6-36.8	34.7 ± 0.48	32.3-38.6	0.42	0.679
<i>pP</i>	25.9 ± 0.22	24.2-27.0	26.7 ± 0.25	24.8-28.7	2.45	0.021
<i>pV</i>	53.1 ± 0.31	50.3-55.0	52 ± 0.35	50.1-54.6	2.26	0.032
<i>pA</i>	73.6 ± 0.33	70.9-75.2	74.1 ± 0.54	69.9-77.7	0.77	0.447
<i>PA</i>	49.1 ± 0.35	46.5-50.6	48.9 ± 0.67	43.6-52.8	0.27	0.790
<i>PV</i>	27.7 ± 0.36	25.1-29.9	25.6 ± 0.41	22.1-28.1	3.84	0.001
<i>VA</i>	22.1 ± 0.29	19.9-24.2	23.9 ± 0.5	19.1-26.4	3.12	0.004
<i>lpc</i>	17.5 ± 0.25	15.3-19.2	17.6 ± 0.36	14.1-19.6	0.26	0.794
<i>lc₁</i>	27.4 ± 0.36	24.8-30.3	27.9 ± 0.44	25.6-32.3	0.72	0.477
<i>lc₃</i>	27.8 ± 0.3	25.8-29.7	29.1 ± 0.39	27.1-31.6	2.52	0.019
<i>hpc</i>	28.2 ± 0.54	24.6-31.1	30.2 ± 0.53	28.3-34.8	2.72	0.012
<i>lapc</i>	0.6 ± 0.02	0.4-0.7	0.7 ± 0.02	0.6-0.8	3.44	0.002
<i>lD</i>	14.4 ± 0.16	13.1-15.5	15.3 ± 0.23	13.8-17.3	3.12	0.004
<i>hD</i>	23.3 ± 0.19	22.1-24.6	23.9 ± 0.57	17.2-26.1	0.98	0.334
<i>hDf</i>	9.0 ± 0.16	7.7-9.9	9.7 ± 0.21	8.2-11.3	2.43	0.022
<i>lA</i>	12.3 ± 0.12	11.6-13.1	12.6 ± 0.23	10.8-14.3	1.03	0.314
<i>hA</i>	15.9 ± 0.22	14.5-17.1	16.9 ± 0.31	15.4-19.9	2.47	0.020
<i>lP</i>	17.3 ± 0.14	16.2-18.1	19.1 ± 0.3	17.2-21.5	5.45	<0.001
<i>lpbs</i>	3.6 ± 0.08	3.0-4.0	3.6 ± 0.11	3.0-4.6	0.19	0.854
<i>th. P</i>	0.6 ± 0.02	0.6-0.7	0.8 ± 0.04	0.6-1.1	4.11	<0.001
<i>lV</i>	17.2 ± 0.16	16.0-18.0	18.3 ± 0.2	17-19.5	4.39	<0.001
<i>lVbs</i>	3.7 ± 0.11	3.2-4.7	4.1 ± 0.1	3.5-5.1	2.69	0.012
<i>V-an</i>	20.4 ± 0.29	18.7-22.1	22.6 ± 0.51	18.8-26.4	3.64	0.001
<i>an-A</i>	1.9 ± 0.13	1.1-3.1	1.5 ± 0.13	0.8-2.3	1.95	0.062
% lc						
<i>ho1</i>	54.1 ± 0.4	52.5-57.0	57.5 ± 0.44	52.9-60	5.59	<0.001
<i>hc</i>	68.7 ± 0.74	64-73.1	73.6 ± 0.59	68.2-76.4	5.20	<0.001
<i>lr</i>	28.3 ± 0.36	25.7-30.7	26 ± 0.28	23.8-27.6	5.07	<0.001
<i>O</i>	26.4 ± 0.4	24.2-29.5	26.5 ± 0.43	24.1-30.6	0.14	0.886
<i>poO</i>	46.6 ± 0.73	41.4-50.2	48.7 ± 0.38	45.9-51.2	2.58	0.016
<i>lac</i>	48.4 ± 0.51	45.0-51.6	49.5 ± 0.49	46.4-52.7	1.62	0.117
<i>io</i>	34.9 ± 1.17	20.9-39.0	36.2 ± 0.36	34.1-39.0	1.12	0.272
<i>lmx</i>	24.4 ± 0.43	21.4-26.9	22.8 ± 0.34	20.5-25.0	2.91	0.007
<i>ina</i>	19.9 ± 0.47	17.0-23.4	20.2 ± 0.42	17.9-24.4	0.42	0.675

characterize the head in the head depth at eye level (*ho*) and maximum head depth (*hc*); these features are significantly larger in *R. rutilus*. Most significantly, *R. virgo* differs in its larger snout length (*lr*) and to a somewhat lesser degree in upper jaw length (*lmx*). *R. rutilus* also differs somewhat from *R. virgo* in its larger

post-orbital distance (*poO*), while all remaining features are similar.

Unlike the measurements presented by Misik (1957) who compared two *Rutilus* species of different size groups (157.39 ± 2.17 mm for *R. rutilus* and 287.25 ± 6.20 mm for *R. virgo*), the fish used in the

Table 3Comparison of morphometric measurements of two size groups of *R. virgo* from the Transcarpathian region of Ukraine

Features	Small (n = 19)		Large (n = 13)		t	P
	mean ± SE	min-max	mean ± SE	min-max		
SL	105.1 ± 9.39	68.5-182.1	286.4 ± 11.7	225.1-346.3	12.15	<0.001
% SL						
TL	104.6 ± 0.94	97.5-119.9	104.8 ± 0.19	103.8-106.0	0.15	0.885
lc	24.5 ± 0.40	21.6-27.0	20.5 ± 0.23	19.1-21.8	7.68	<0.001
H	27.1 ± 0.44	23.9-31.4	30.9 ± 0.67	26.2-34.7	5.04	<0.001
h	9.9 ± 0.09	9.1-10.6	10.1 ± 0.12	9.1-10.7	1.60	0.121
iH	13.0 ± 0.18	11.5-14.6	13.8 ± 0.14	12.7-14.4	2.95	0.006
ih	4.3 ± 0.17	3.1-5.9	5.2 ± 0.13	4.5-6.2	4.27	<0.001
aD	53.4 ± 0.45	47.5-57.3	53.6 ± 0.42	50.8-56.1	0.28	0.780
poD	36.0 ± 0.55	33.6-43.3	39.8 ± 0.52	37.2-42.8	4.80	<0.001
pP	25.4 ± 0.29	22.4-27.0	22.6 ± 0.26	21.1-24.4	6.78	<0.001
pV	53.1 ± 0.3	50.3-55.7	54.4 ± 0.49	51.3-57.1	2.39	0.023
pA	74.2 ± 0.41	70.9-78.8	77.8 ± 0.64	74.0-81.2	4.97	<0.001
PA	50.4 ± 0.62	46.5-56.9	55.3 ± 0.67	52.3-59.5	5.26	<0.001
PV	28.6 ± 0.47	25.1-33.0	33.0 ± 0.36	31.0-35.3	6.89	<0.001
VA	22.7 ± 0.37	19.9-26.6	24.2 ± 0.41	21.7-26.6	2.63	0.013
lpc	18.4 ± 0.43	15.3-22.5	20.0 ± 0.3	17.5-21.6	2.74	0.010
lc ₁	26.3 ± 0.52	22.5-30.3	22.7 ± 0.38	20.2-24.9	5.17	<0.001
lc ₃	26.8 ± 0.49	23.4-29.7	22.6 ± 0.39	19.9-24.9	6.23	<0.001
hpc	30.9 ± 1.28	24.6-43.0	41.4 ± 0.75	37.2-46.1	6.41	<0.001
lapc	0.6 ± 0.02	0.4-0.7	0.6 ± 0.02	0.4-0.8	0.79	0.437
lD	14.6 ± 0.15	13.1-16.2	14.8 ± 0.18	13.7-15.8	0.88	0.388
hD	23.1 ± 0.22	20.1-24.6	22.0 ± 0.3	20.4-23.9	3.01	0.005
hDf	8.9 ± 0.14	7.7-9.9	8.9 ± 0.16	7.8-10.1	0.02	0.981
lA	12.2 ± 0.14	11.1-13.1	12.4 ± 0.17	11.5-13.4	1.28	0.210
hA	15.4 ± 0.26	13.2-17.1	13.6 ± 0.16	12.2-14.3	5.28	<0.001
lP	17.1 ± 0.16	15.1-18.1	16.5 ± 0.14	15.5-17.7	3.07	0.005
lpbs	3.8 ± 0.09	3-4.6	4.5 ± 0.06	4.0-4.9	5.51	<0.001
th. P	0.6 ± 0.01	0.6-0.7	0.7 ± 0.02	0.6-0.9	4.60	<0.001
lV	17.3 ± 0.17	16-18.8	16.3 ± 0.2	15.2-17.6	3.91	0.001
lVbs	3.9 ± 0.11	3.2-4.8	5.1 ± 0.1	4.4-5.5	7.34	<0.001
% lc						
ho1	52.7 ± 0.77	44.0-57.0	50.6 ± 1.18	44.2-58.5	1.49	0.146
hc	70.0 ± 0.79	64.0-77.4	76.6 ± 1.23	70.6-85.3	4.75	<0.001
lr	27.5 ± 0.44	23.3-30.7	28.8 ± 0.41	26.8-31	2.22	0.034
O	26.0 ± 0.38	22.6-29.5	20.9 ± 0.35	18.8-23	9.38	<0.001
poO	46.7 ± 0.56	41.4-50.2	48.7 ± 0.31	47.3-50.7	2.75	0.010
lac	49.7 ± 0.68	45.0-56.1	53.7 ± 0.55	49.8-56.9	4.25	<0.001
io	36.4 ± 0.46	32.9-39.6	39.0 ± 0.56	36.2-42.6	3.53	0.001
lmx	23.9 ± 0.45	20.6-26.9	22.9 ± 0.45	20.1-25.2	1.72	0.095

present work were of nearly the same size, which permitted for more distinct highlighting of the features that differ in these two similar species. Compared to Misik's (1957) data, the present results of morphometric measurements do not indicate such noticeable differences between *R. rutilus* and *R. virgo*. However, it is noteworthy that both comparisons of this pair demonstrated similar tendencies in

features such as head depth and length (*lc* and *hc*), body depth (*H*), body length (*TL*), and pectoral fin length (*lP*). Some features, including preanal length, anal fin depth, eye diameter, and others, were more varied in different size groups of the same species (e.g., *R. virgo* Table 3) than they were in the two *Rutilus* species. These two species differ most in meristic characters in the number of scales in the

Table 4Comparison of meristic characters of *R. virgo* and *R. rutilus* from the Transcarpathian region of Ukraine

Features	<i>R. virgo</i>			<i>R. rutilus</i>			t	P
	n	mean ± SE	min-max	n	mean ± SE	min-max		
<i>ll.</i>	32	46.8±0.18	45-49	18	42.1±0.21	41-43	16.4	<0.001
<i>ll. with pores</i>	32	45.6±0.15	44-47	18	40.7±0.18	40-42	19.84	<0.001
<i>ll. without pores</i>	32	1.3±0.12	0-3	18	1.4±0.14	1-3	0.73	0.472
<i>Du</i>	32	3±0.03	2-3	18	3		0.75	0.459
<i>Db</i>	32	10.7±0.07	10.5-11.5	18	10.3±0.1	9.5-10.5	3.19	0.002
<i>Au</i>	32	2.9±0.04	2-3	18	3		1.07	0.288
<i>Ab</i>	32	11.6±0.12	10.5-13.5	18	10.4±0.08	9.5-10.5	6.98	<0.001
<i>P</i>	20	16.6±0.18	14-18	18	15.4±0.27	13-17	3.43	0.002
<i>V</i>	20	18.1±0.05	18-19	18	17.9±0.06	17-18	1.42	0.165
<i>C</i>	20	18.8±0.14	17-19	18	18.9±0.08	18-19	0.55	0.587
<i>Squ₁</i>	32	7.8±0.08	7-8	18	8.1±0.08	8-9	3.04	0.004
<i>Squ₂</i>	32	4.5±0.1	4-6	18	4		3.96	<0.001
<i>cir</i>	31	14±0.07	13-15	18	13.9±0.13	13-15	0.43	0.669

lateral line, the values of which were higher in *R. virgo* (Table 4). The differences in the number of scales with pores in the lateral line were much larger, while the number of scales without pores was almost the same in both species. These fishes also differed in the number of scales under and above the lateral line. No differences between the two species were noted in the number of unbranched rays in all the fins. As for branched rays, the largest difference was observed in the branched rays of the anal fin (*Ab*) and to a somewhat lesser degree for those in the dorsal fin (*Db*). A difference was also observed in the number of branched rays in the pectoral fin (*P*). The number of branched rays in the pelvic and caudal fins were similar in both species. Overall, the results in the present study of the comparison of meristic characters are fully consistent with those obtained by Misik (1957), who also found significant differences between the two *Rutilus* species in the number of scales in the lateral line (*ll.*) and the number of branched rays in the anal (*Ab*) and pectoral (*P*) fins.

The comparison of two samples of *R. virgo* from different size groups showed that a number of changes occur in body proportions during growth (Table 3). The features of 19 fish with an average length of 105.1

mm were compared to those of 13 fish with an average length of 286.4 mm. Relative changes in virtually all examined morphometric features was noted. Features such as maximum body depth (*H*), maximum body width (*iH*), and depth of caudal peduncle (*hpc*) increased; however, the minimum body depth (*h*) remained unchanged. The most significant reduction in length was noted in the head during ontogenesis. Fish growth caused increases in relative features, which was reflected in fin locations (*poD*, *pV*, *pA*, *PA*, *PV*, *VA*, *lpc*), but, predorsal length (*aD*) remained unchanged, while prepectoral length (*pP*) even decreased, which was probably linked with the relative reduction in head length. The upper and lower caudal peduncle lobes (*lC₁* and *lC₃*) reduce in length with growth, while the relative caudal peduncle depth increased (*hpc*) at its unchanged width (*lapc*). The maximum dorsal fin length (*hD*) decreased, but the length (*lD*) and depth of its posterior edge (*hDf*) remained unchanged. The measurements of the anal fin changed similarly. The length of the pectoral and pelvic fins (*lP* and *lV*) reduced as the fish grew in parallel with increased base length. The relative thickness of the pectoral fins also increased. Changes in head measurements were observed in all features examined

Table 5Fecundity parameters of *R. virgo* from the Transcarpathian region of Ukraine (November 2011)

No	Age (years)	Standard length (mm)	Body weight (g)	Gonad weight (g)	Absolute fecundity (eggs)	Relative fecundity (eggs g ⁻¹)
1	4+	225.1	237	15.28	6775	28.6
2	4+	253.0	312	23.80	10543	33.8
3	6+	285.0	505	48.50	20370	40.3
4	6+	300.0	606	60.32	26907	44.4
5	6+	300.0	624	61.70	27333	43.8
6	7+	344.7	893	83.27	39986	44.8
7	8+	346.3	912	105.70	45153	49.5
8	8+	331.5	891	116.07	51535	57.8
Mean		298.2	622.5	64.33	28575	42.9

except in head depth above eye level (*ho1*) and length of upper jaw (*lmx*). Relative head depth and width (*hc* and *lac*) increased with interorbital length (*io*). Snout length (*lr*) and postorbital length (*poO*) increased with head length growth because of the reduction in eye diameter (*O*) relative to head length. The relative increase in certain features as the fish grew, such as snout length (*lr*) or postorbital length (*poO*), occurs in cyprinids as an adaptation related to changes in biotope (i.e., the move from the littoral to the profundal zone) and predation on larger benthic organisms (Zhiteneva 2002). Similar increases of various features and other body proportions were also noted in *R. virgo*: *iH*, *ih*, *poD*, *pA*, *PA*, *VA*, *lpc*, *hpc*, *lpbs*, *th.P*, *IVbs*, *hc*, *lac*, *io*. The relative lengths of other features (*h*, *aD*, *hDf*, *LA*, *ho1*, *lmx*) did not change with fish growth, and the rest of the relative lengths of parameters decreased during fish ontogenesis.

The comparison of the current data with those in the literature (Misik 1957), namely fish of an average size of 286.4 mm collected in Ukraine (Table 3) and fish of an average size of 287.25 mm collected in Slovakia, indicated high similarity. Features such as interorbital length (*io*), horizontal eye diameter (*O*), length of head (*lc*), maximum body depth (*H*), and body width (*iH*), length of caudal peduncle (*lpc*), minimum body depth (*h*), length of anal fin base (*LA*) and anal fin depth (*hA*), and distance between the bases of the pelvic and anal fins (*VA*) were all nearly the same. Other features varied slightly: the lengths

of the pectoral (*IP*) and ventral (*IV*) fins and the maximum depth of the dorsal fin (*hD*) were larger in fish collected in the Transcarpathian region, while postorbital distance (*pO*) and length of caudal peduncle (*lc*) were larger in fish collected in the Danube, the Little Danube, and the Hron (Misik 1957). These differences can be attributed to the fact that they were measured by different researchers. However, a few features were significantly different: the pectroventral (*PV*), preventral (*pV*), and preanal (*pA*) distances were larger in fish from Ukraine, while length of snout (*lr*) and head width (*lac*) were smaller. The largest difference was maximum head depth (*hc*), which was only 76.6% of *lc* in fish from the Transcarpathian region, while in the fish collected by Misik (1957) it was 87.2% of *lc*.

The length-weight relationship for mixed sexes of *R. virgo* was: $a = 0.0157$, $b = 3.088$ (min *SL* = 3.2 cm, max *SL* = 34.6 cm; min *W* = 0.58 g, max *W* = 912.0 g; $n = 31$; $r^2 = 0.9988$). The fecundity of *R. virgo* caught in the Borzhava River depended on age and ranges from 6775 to 51535 eggs (Table 5); this is quite consistent with data reported in the literature for cactus roach at 25000-30000 eggs (Holčík 1995). However, *R. virgo* fecundity was much lower compared to that of *R. rutilus*. For example, the absolute fecundity of roach (*SL* ≥ 30 cm) inhabiting the Dnieper River reservoirs usually exceeds 100000 eggs (Movchan and Smirnov 1981). Of the 13 fish caught in the Borzhava River, 8 were females and 5 were males.

Table 6Growth parameters of *R. virgo* from the Transcarpathian region of Ukraine

Age	n	Standard length (cm)		Body weight (g)		Fulton condition factor
		mean	min-max	mean	min-max	
1+	4	7.08	6.85-7.19	6.6	5.3-7.4	1.86
2+	9	8.47	7.40-11.86	12.3	7.8-28.3	2.03
3+	3	15.18	11.86-17.17	74.4	33.2-107.0	2.13
4+	4	20.36	17.51-23.20	178.3	109.0-246.0	2.11
5+	2	25.06	24.35-25.76	306.5	257.0-356.0	1.95
6+	5	28.36	28.0-30.0	498.8	312.0-624.0	2.19
7+	1	34.7	34.7	893.0	893.0	2.18
8+	2	33.89	33.2-34.6	901.5	891.0-912.0	2.32

Table 7Habitat characteristics of *R. virgo* catch locations

River	Borzhava	Latorica	Latorica
Placement	village of Bene	village of Solomonovo	
Coordinates	48°09'48"N 22°46'44"E	48°27'3"N 22°10'10"E	48°27'24"N 22°10'18"E
Width of the river (m)	30	16	15-33
Depth of the river (m)	2.5-4	1-2	1-3
Velocity (m s ⁻¹)	0.1	0.1	0.1
Bottom surface	snagged, silted	sandy-clayey with isolated silted areas	snagged, clayey
Aquatic vegetation	submerged aquatic vegetation (<i>Potamogeton</i> sp.)	n/a	n/a
Banks	steep and covered with trees and bushes	densely covered with trees	densely covered with trees
Channel structure	snagged by trees falling into the water from clearing banks of vegetation	the river channel greatly meanders in this reach forming multiple oxbows, <i>R. virgo</i> was found only in mainstream	the river channel greatly meanders in this reach forming multiple oxbows, <i>R. virgo</i> was found only in mainstream
Syntopic species	<i>Squalius cephalus</i> , <i>I. idus</i> , <i>Chondrostoma nasus</i> , <i>Alburnus alburnus</i> , <i>Blicca bjoerkna</i> , <i>Abramis brama</i> , <i>Ballerus sapa</i> , <i>Aspius aspius</i> , <i>Barbus barbus</i> , <i>Cobitis elongatoides</i> , <i>Silurus glanis</i> , <i>Esox lucius</i> , <i>Sander lucioperca</i>	<i>S. cephalus</i> , <i>R. rutilus</i> , <i>A. bipunctatus</i> , <i>A. alburnus</i> , <i>B. bjoerkna</i> , <i>Romanogobio vladykovi</i> , <i>S. glanis</i> , <i>E. lucius</i> , <i>Lepomis gibbosus</i> , <i>Perca fluviatilis</i> , <i>Gymnocephalus baloni</i>	<i>A. bipunctatus</i> , <i>G. baloni</i> , <i>P. fluviatilis</i> , <i>R. vladykovi</i> , <i>R. rutilus</i>
Remarks	there is a dam located 5 km downstream (built in 1892) by which the water level in the sampling sites in spring raises by approx. 1 m	great amounts of snags and litter of human origin (plastic bottles, bags, etc.) in the river channel	great amounts of snags and litter of human origin (plastic bottles, bags, etc.) in the river channel

R. virgo inhabiting rivers of the Transcarpathian region was characterized by a relatively rapid growth rate (Table 6), and the present results were within the growth rate limits reported in the literature (Holčík 1995). However, the mean age values of fish older than 5+ are somewhat higher. It is necessary to note that the fish studied were caught in different seasons (mid-summer and late autumn), and the samples were relatively small, and this probably resulted in some inconsistency, e.g., differences between age 1+ and 2+ fish were very small, while 7+ fish were a little bit longer than fish aged 8+. Because the fish in the Bozrhava River were caught at the end of November, individuals aged 3+ to 8+ can be considered to be fish aged from 4+ to 9+. The growth rate of *R. virgo* seemed to be higher than that of *R. rutilus* in Ukrainian water bodies, e.g., roach aged 5+ and 6+ rarely exceeds 20 cm in Ukrainian rivers and reservoirs (Movchan and Smirnov 1981). Habitat characteristics are presented in Table 7. *R. virgo* juveniles (aged 0+, 1+, 2+) were observed in shallow waters of the Latorica River channel at night (20:00-03:00) in summer (July). They fed actively and reacted to electric light, but they remained on site, while larger individuals escaped to the depths. During winter, fish caught using gill nets (older age groups) did not feed; however, some individuals aged 1+ to 4+ were caught with angling gears, and this indicates feeding activity in this species during this period.

In conclusion, *R. virgo* can be officially listed in the fauna of Ukraine for the Transcarpathian region (Zakarpatska oblast) in rivers that belong to the Tisza River drainage basin. Additional studies are necessary to identify in more detail the distribution range and biological characteristics of this rare species in this location.

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