

Two new *Barbus* species from the Danube River basin, with redescription of *B. petenyi* (Teleostei: Cyprinidae)

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Abstract. Three rheophilic species of the western Palaearctic *Barbus* with adjacent geographic distributions are recognised in the Danube River basin, each diagnosed by a set of unique mitochondrial DNA alleles. *Barbus petenyi* Heckel, 1852 from the Eastern and Southern Carpathians and from the Stara Planina Mts is redescribed and a neotype is designated. *Barbus carpathicus*, new species, is distributed in the Western and Eastern Carpathians. *Barbus balcanicus*, new species, occurs in the Dinaric and Western Stara Planina Mts. The three species are morphologically similar to each other but *B. balcanicus* can be distinguished by subtle differences in the snout shape and body and fin colour pattern. As evident from genetic data the name *B. cyclolepis waleckii* Rolik, 1970 was proposed for the hybrids between *B. barbus* and *B. carpathicus* and cannot be used as valid.

Key words: taxonomy, nomenclature, neotype, mtDNA, *Barbus petenyi*, *Barbus carpathicus*, *Barbus balcanicus*, *Barbus cyclolepis waleckii*

Introduction

The evolutionary history and systematics of the Old World freshwater fish genus *Barbus* Cuvier et Cloquet, 1816 (barbs) are contested and still only inadequately understood (Berrebi 1995, Berrebi et al. 1996). It is now well established that the genus is polyphyletic and embodies several diploid, tetraploid and hexaploid lineages (Berrebi et al. 1996, Tsigenopoulos & Berrebi 2000, Machordom & Doadrio 2001, Tsigenopoulos et al. 2002a), of which the western Palaearctic lineage of evolutionarily tetraploid species is demonstrably monophyletic, and is referred to as the genus *Barbus* sensu stricto (Doadrio 1990, Berrebi et al. 1996, Machordom & Doadrio 2001).

Barbus petenyi belongs to the group of small-sized rheophilic species of the western Palaearctic barbs (Tsigenopoulos et al. 1999, Tsigenopoulos & Berrebi 2000). Heckel described this species in 1852 (for discussion of the publication date, see Kottelat 1997) from the Danube River basin in Siebenbürgen (= Transylvania) in present-day Romania (Fig. 1). Since, shortly after that date, the fish has been considered widely distributed throughout the mountain regions in the Danube River basin and several

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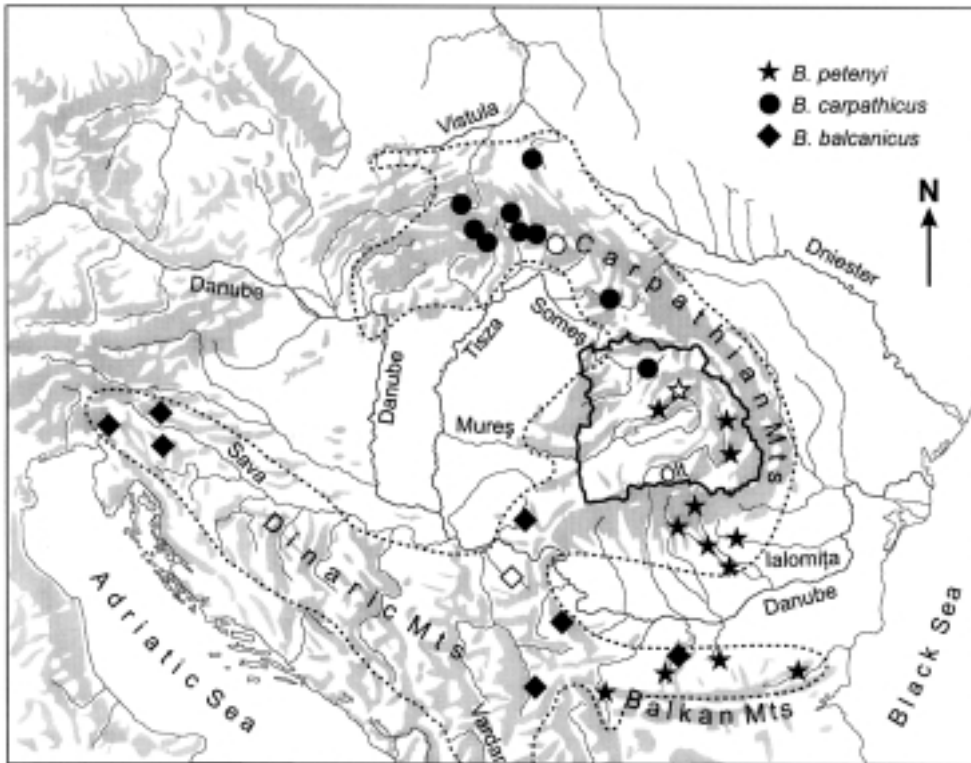


Fig. 1. Localities where the three Danubian species of rheophilic barbs have been identified on the basis of genetic data (Kotlík & Berrebi 2002), including their type localities (empty symbols). Another such populations of *Barbus balcanicus* occur off the map to the south in the Vardar River, Gallikos River, Aliakmon River and Vegoritis Lake in northern Greece (see text for details). Thick black line outlines the historical area of Transylvania. Dotted line delimits the distribution of the Danubian rheophilic barbs as compiled from the zoogeographical data provided by Bănărescu (1964, 1991), Kux (1964), Harka (1997), Boroń (2000) and Simonović & Nikolić (1996).

adjacent drainages (e.g. Heckel & Kner 1858, Berg 1949, Bănărescu 1964, Boroń 2000; see Fig. 1). Although originally described as a species, most subsequent authors (but see, e.g. Starmach & Rosół 1961, Rembiszewski & Rolik 1975) have considered it a subspecies of *B. meridionalis* Risso, 1826, a species from southern France and northeastern Spain (Steindachner 1882, Berg 1949, Bănărescu 1957, 1964), or of *B. peloponnesius* Valenciennes, 1842, a species from Greece (Karaman 1971, Karakousis et al. 1993, 1995, Boroń 2000). Only recently has *B. petenyi* again been recognised as a full species (Tsigenopoulos et al. 1999, Tsigenopoulos & Berrebi 2000, Machordom & Doadrio 2001).

The evolutionary history of *B. petenyi* inferred from the variation at nuclear (Tsigenopoulos et al. 1999, Tsigenopoulos et al. 2002b) and mitochondrial genes (Tsigenopoulos & Berrebi 2000, Machordom & Doadrio 2001, Kotlík & Berrebi 2002) revealed three groups of populations, which have been evolving independently of one another and of all the other *Barbus* species since the Pliocene and are differentiated at the species level (Kotlík & Berrebi 2002). The

aims of this paper are to: (1) clarify the nomenclatural status of the name *B. petenyi*, (2) redescribe this taxon on the basis of a recently obtained material, and (3) formally describe the two new species.

Material and Methods

In total 24, 22 and 24 individuals of *B. petenyi*, *B. carpathicus* and *B. balcanicus*, respectively, were examined, including the specimens used in the previous genetic analyses (K o t l í k & B e r r e b i 2002). Twenty-nine measurements were taken using an electronic digital calliper (0.1 mm accuracy) and seven meristic characters were recorded on the material preserved in ethanol or formaldehyde (on the left side of a specimen whenever possible), following methods described by H o l č í k (1989). Only individuals of the standard length (SL) 110 mm or more were measured. Specimens studied were deposited in the following collections: collection of Petr K o t l í k , Liběchov, Czech Republic (PK); collection of Maurice K o t t e l a t , Cornol, Switzerland (CMK); Muséum National d'Histoire Naturelle, Paris (MNHN); Naturhistorisches Museum Wien (NMW); Zoologisches Forschungsinstitut und Museum Alexander Koenig, Bonn (ZFMK). Mitochondrial DNA (mtDNA) alleles are referred to under their accession numbers in the GenBank sequence database (B e n s o n et al. 2000).

Barbus petenyi Heckel, 1852

Barbus Petenyii (*sic*) (*nomen nudum*); H e c k e l 1848: 194)

Barbus Petenyi Heckel, 1852: 29 (type locality: Romania: Transylvania: Mureş River at Răstoliţa; neotype: NMW-94602, by present designation; see below)

Pseudobarbus Leonhardi Bielz, 1853: 179 (new replacement name)

M a t e r i a l e x a m i n e d . All from Danube River basin. NMW-94602 and NMW-94603: 1–3 (formerly PK726 and PK729–731; field nos. 21 and 24–26), 4 ex., 81.0–135.0 mm SL; Romania: Transylvania: Mureş River at Răstoliţa, approximately 46°58'N, 25°00'E; P. Kotlík, D. Hanganu, N. Crăciun & G. Veress, 27 September 1998. – PK717–725 (field nos. 12–20), 9 ex., 97.0–142.0 mm SL; Romania: Transylvania: Mureş River at Stancenii; P. Kotlík, D. Hanganu, N. Crăciun & G. Veress, 27 September 1998. – PK794–801 (field nos. 89–96), 8 ex., 87.0–116.0 mm SL; Romania: Transylvania: Olt River at Olteni; P. Kotlík, D. Hanganu & N. Crăciun, 29 September 1998. – MNHN 2001–2676 (formerly PK788–790; field nos. 83–85), 3 ex., 121.0–143.0 mm SL; Romania: Transylvania: Jambor River, tributary of Olt River, at Bixad; P. Kotlík, D. Hanganu & N. Crăciun, 29 September 1998.

D i a g n o s i s . *Barbus petenyi* is distinguished from all other *Barbus* species by the following mtDNA alleles: AF112431 and AF248725–30 (mtDNA lineage C of K o t l í k & B e r r e b i 2002; Table 1). Although there is overlap in most morphological characters, *B. petenyi* is distinguished from *B. balcanicus* in having sharply pointed (vs. bluntly pointed) snout, small dark brownish spots on back and flanks and, to a lesser extent, head (vs. large brownish-black spots on head, back and flanks, which on head extend downwards to cheeks), and finely spotted unpaired and unspotted paired fins (vs. all fins heavily dark spotted with spots typically arranged into rows on dorsal and caudal fins and into band on ventral fins).

D e s c r i p t i o n . General body shape and appearance are shown in Fig. 2 and morphometric characteristics are summarized in Table 2. Snout sharply pointed. Dorsal fin with 3



Fig. 2. *Barbus petenyi*, NMW-94602, neotype, 135.0 mm SL; Romania: Mureș River at Răstolița (right body side; specimen deformed).

unbranched rays, last one always soft, not serrated along posterior margin, and 7 (4) or 8 (20) branched rays, last one split to base; outer margin straight or slightly concave. Anal fin with 1 (12) or 2 (10) unbranched and 4 (1) or 5 (23) branched rays, last one split to base; when depressed, reaching to between middle of caudal peduncle and middle of caudal fin lobe. There are 52–59 (mean 55.5, SD 2.3) pored scales along lateral line; 8 (1), 9 (5), 10 (10) or 11 (4) scale rows above lateral line; 8 (3), 9 (11) or 10 (2) scale rows below lateral line. Coloration of preserved specimens dark greyish-brown on back, flanks yellowish brown, belly yellowish white; back, flanks and, to a lesser extent, head, with small dark brownish spots, irregularly grouped; unpaired fins finely dark spotted; peritoneum black. Karyotype not studied, diploid chromosome number of $2n = 100$ can be expected (B e r r e b i et al. 1996).

Geographical distribution. The species is known from the mountain and submountain brooks and rivers of the Middle Tisza River, a major northern tributary of the Middle Danube River, and the Lower Danube River basins in the Eastern and Southern Carpathians in Romania (Fig. 1). The northernmost known populations are in the Mureș River, an eastern tributary of the Tisza River, in Transylvania. It further occurs in the tributaries of the Lower Danube River in the Stara Planina (= Balkan) Mts in Bulgaria (K o t l í k & B e r r e b i 2002). The only known occurrence outside the Danube River basin is in the Kamtchya River basin of the Black Sea drainage in the Eastern Stara Planina Mts in Bulgaria (K o t l í k & B e r r e b i 2002), which represents the southeastern limit of the species' known distribution.

***Barbus carpathicus*, new species**

H o l o t y p e . NMW-94604 (formerly PK521, field no. 7273), 110.0 mm SL; Slovakia: Danube River basin: Ublianka River, tributary of Uzh River, at Ubľa, 48°53'N, 22°23'E; V. Šlechta & P. Kotlík, 9 October 1998.

P a r a t y p e s . Danube River basin. NMW-94605 (formerly PK520; field no. 7272), 1 ex., 117.0 mm SL; same data as holotype. – NMW-94606: 1–2 (formerly PK552–553; field nos. 7364–7365), 2 ex., 114.0–117.0 mm SL; Slovakia: Cirocha River, tributary of Laborec River, at Dlhé nad Cirochou; V. Šlechta & P. Kotlík, 11 October 1998. – MNHN 2001–2674 (formerly PK587–588; field nos. 7399–7400), 2 ex., 138.0–146.0 mm SL; Slovakia: Výrava River, tributary of Laborec River, at Zbojné; V. Šlechta & P. Kotlík, 12 October 1998. – MNHN 2001–2811 (formerly PK624–625; field nos. 7436–7437), 2 ex., 154.0–164.0 mm



Fig. 3. *Barbus carpathicus*, NMW-94604, holotype, 110.0 mm SL; Slovakia: Ublianka River at Ubla.

SL; Slovakia: Torysa River at Krivany; V. Šlechta & P. Kotlík, 14 October 1998. – Vistula River basin: NMW-94607: 1–3 (formerly PK222–224; field nos. 6101–6103), 3 ex., 140.0–177.0 mm SL; Slovakia: Poprad River at Hromoš; P. Ráb, V. Šlechta & P. Kotlík, 23 October 1997. – NMW-94608: 1–3 (formerly PK109–111; field nos. 5945–5947), 3 ex., 142.1–164.0 mm SL; Slovakia: Lubotínka River, tributary of Poprad River; P. Ráb, V. Šlechta & P. Kotlík, 22 October 1997. – MNHN 2001–2812 (formerly PK1–2 and PK4; field nos. 5812–5813 and 5815), 3 ex., 108.0–166.0 mm SL; Slovakia: Poprad River at Orlov; P. Ráb, V. Šlechta & P. Kotlík, 21 October 1997. – MNHN 2001–2813 (formerly PK102–104; field nos. 5929–5931), 3 ex., 146.3–181.0 mm SL; Slovakia: Poprad River at Plaveč; P. Ráb, V. Šlechta & P. Kotlík, 21 October 1997. – CMK 17001 (formerly PK40–41; field nos. 5851–5852), 2 ex., 167.0–186.0 mm SL; Slovakia: Poprad River at Andrejovka; P. Ráb, V. Šlechta & P. Kotlík, 21 October 1997.

Diagnosis. *Barbus carpathicus* is distinguished from all other *Barbus* species by the following mtDNA alleles: AF112127 and AF248722–23 (mtDNA lineage B of Kotlík & Berrebi 2002; Table 1). Although there is overlap in most morphological characters, *B. carpathicus* is distinguished from *B. balcanicus* in having sharply pointed (vs. bluntly pointed) snout, small dark brownish spots on back and flanks and, to a lesser extent, head (vs. large brownish-black spots on head, back and flanks, which on head extend downwards to cheeks), and finely spotted unpaired and unspotted paired fins (vs. all fins heavily dark spotted with spots typically arranged into rows on dorsal and caudal fins and into band on ventral fins).

Description. General body shape and appearance are shown in Fig. 3 and morphometric characteristics are summarized in Table 2. Snout sharply pointed. Dorsal fin with 2 (3) or 3 (19) unbranched rays, last one always soft, not serrated along posterior margin, and 7 (4) or 8 (18) branched rays, last one split to base; outer margin straight or slightly concave. Anal fin with 1 (14) or 2 (7) unbranched and 4 (13) or 5 (8) branched rays, last one split to base; when depressed, reaching to between middle of caudal peduncle and middle of caudal fin lobe. There are 51–64 (mean 54.9, SD 3.0) pored scales along lateral line; 8 (4), 9 (7), 10 (10) or 11 (1) scale rows above lateral line; 8 (16) or 9 (1) scale rows below lateral line. Coloration of preserved specimens dark greyish-brown on back, flanks yellowish brown, belly yellowish white; back, flanks and, to a lesser extent, head, with small dark

Table 1. DNA sequences of the first 594bp of the mitochondrial cytochrome *b* gene of *Barbus petenyi* (allele AF112431 carried by the neotype), *B. carpathicus* (allele AF112127 carried by the holotype) and *B. balcanicus* (allele AF248717 carried by the holotype). The sequence of *B. petenyi* is shown at all sites, the nucleotide bases in the other two sequences are shown only where different; dots indicate bases identical with the *B. petenyi* sequence.

<i>B. petenyi</i>	ATGGCAAGCC	TACGAAAAAC	ACACCCCCTA	ATTAAAATTG	CTAACAGCGC	ACTAGTTGAC
<i>B. carpathicus</i>	.....	.....	G.....T..	.....	.....A...	.....
<i>B. balcanicus</i>	.....	.....	.....T..	.....	.....A...	.....
61 CTACCAGCAC	CATCTAATAT	CTCAGCTTGA	TGAAACTTTG	GTTCTCTCCT	AGGACTATGC	TTAGTACTCT
.....	.....	T...T...G	.....	.C.....	.....	.....
.....	.....C..	T...T...	.....	.C.....	.....	.....
131 AGATCCTTAC	CGGCCTATTC	TTAGCCATAC	ACTACACCTC	AGATAATTCG	ACCGCATTTT	CATCAGTCGT
.A.....	.....	.....G..	.....	G.....A	.....	.....T..
.A.....	.....	.....	.....	.....	.....	.....
201 CCACATCTGC	CGAGATGTAA	ATTACGGCTG	ACTGATCCGT	AACATGCACG	CCAACGGAGC	ATCATCTCTT
T..T.....	..G.....	.C.....	.....	..T.....	.....	.....
T..T..T..	.....G..	.C.....	..A.....	..T..A...	.....	.....
271 TTCCTTTGCA	TCTACATACA	CATTGCCCGA	GGACTATACT	ACGGCTCTTA	CCTCTACAAA	GAAACCTGAA
.....	.....	.....	.....	.T.....	..T..T..	.....
.....	..T..T...	.....	.....	.....	.....T..G	.....
341 ACATCGGCGT	AGTCTCCTC	CTATTAGTCA	TAGCAACAGC	TTTCGTTGGC	TACGFACTCC	CGTGAGGCCA
...T.....	GA...T..T	A.GC...T.	...G.G..	C.....	..T.....	.....A..
...T..A..	.....G	..GC...T.	...G..	C.....	..T.....	..A...A..
411 AATATCCTTC	TGAGGCGCCA	CAGTAATTAC	GAATCTCTTC	TCCGCCGTAC	CATACATAGG	GGACATACTG
.....T...	.....	.....	A.....C..	.....	...T.....	A..T....A
...G..T..T	.....	.....	A.....	.....	.....	A..T....A
481 GTACAGTGAA	TCTGAGGTGG	ATTTTCAGTA	GATAACGCAA	CGCTGACACG	ATTCTTCGCA	TTTCACTTCC
..C..A...	.....	G.....	..C.....	.A....G..	.....	.....
..C..A...	.....	G..C.....	..C.....	.A..A..G..	.....	.....
551 TTCTACCATT	TATTATTGCC	GCCGCAACCA	TTCTACACCT	CCTG		
.A.....	C.....T	..A.....	.....	....
.....	C.....T	..T.....	.....	....

brownish spots, irregularly grouped; unpaired fins finely dark spotted; peritoneum black. Diploid chromosome number of $2n = 100$ reported for populations from the Vistula River (Valenta et al. 1979) and Danube River basins (Ráb et al. 1993) in Slovakia.

Etymology. Named after the Carpathian Mts, to the northwestern part of which the distribution range of the species is restricted. An adjective.

Geographical distribution. The known distribution is limited to the mountain and submountain brooks and rivers in the Western and Eastern Carpathians (Fig. 1). Most of the distribution range is in the drainage of the Upper Tisza River, and includes Slovakia, Poland, Romania, and apparently also Hungary (Harka 1997). Outside the Danube River basin, the known populations are in the Upper Vistula River basin in Slovakia and Poland, and apparently also in the Upper Dniester River basin in Poland (Roliik 1967a, cited in Rembiszewski & Roliik 1975). Westernmost limit of the distribution range appears

the drainage of the Hron River, the northern tributary of the Middle Danube River, in Slovakia (K u x 1964), and the headwaters of the Vistula River in Poland (S t a r m a c h & R o s ó ł 1961). In the southeast, the known distributional limit is the drainage of the Someş River, a southern tributary of the Upper Tisza River, in Transylvania (K o t l í k & B e r r e b i 2002). Isolated specimens of a rheophilic barb were repeatedly recorded in the Upper Danube River basin in Austria (Z a u n e r 1998), which may belong to *B. carpathicus*.

***Barbus balcanicus*, new species**

H o l o t y p e . NMW-94609 (formerly PK317), 130.0 mm SL; Yugoslavia: Serbia: Danube River basin: Krupaja River, tributary of Mlava River, at Milanovac, near Krepoljin, approximately 44°16'N, 21°37'E; P. D. Simonović, 1998.

P a r a t y p e s . All from Danube River basin. NMW-94610 (formerly PK313), 1 ex., 98.0 mm SL; same data as holotype. – NMW-94611: 1–2 (formerly PK384–85), 2 ex., 142.0–145.0 mm SL; Slovenia: Kamnica Creek at Dolsko; P. Župančič, 14 August 1999. – CMK 17002 (formerly PK405–406), 2 ex., 118.0–127.0 mm SL; Bulgaria: Archar River; M. Zhivkov, 1998. – MNHN 2001–2675 (formerly PK407–409), 3 ex., 118.0–127.0 mm SL; Bulgaria: Archar River; M. Zhivkov, 1998. – ZFMK 22321–22335, 15 ex., 94.0–174.0 mm SL; Romania: Banat: Nera River at Sasca Montană; J. Freyhof, A. Nolte & J. Bohlen, 5 April 1998.

D i a g n o s i s . *Barbus balcanicus* is distinguished from all other *Barbus* species by the following mtDNA alleles: AF112122, AF112409, AF112413–14, AF112438, AF248717–19 and AF274351 (mtDNA lineage A of K o t l í k & B e r r e b i 2002; Table 1). Although there is overlap in most morphological characters, *B. balcanicus* is distinguished from *B. petenyi* and *B. carpathicus* in having a bluntly pointed (vs. sharply pointed) snout, large brownish-black spots on head, back and flanks, which on head extend downwards to cheeks (vs. small dark brownish spots on back and flanks and, to a lesser extent, head), and all fins heavily dark spotted with spots typically arranged into rows on dorsal and caudal fins and into band on ventral fins (vs. finely spotted unpaired and unspotted paired fins).

D e s c r i p t i o n . General body shape and appearance are shown in Fig. 4 and morphometric characteristics are summarized in Table 2. Snout typically bluntly pointed. Dorsal fin with 2 (3) or 3 (21) unbranched rays, last one always soft, not serrated along posterior margin, and 7 (2) or 8 (22) branched rays, last one split to base; outer margin straight or slightly concave. Anal fin with 1 (2), 2 (10) or 3 (4) unbranched and 4 (8) or 5 (16) branched rays, last one split to base; when depressed, reaching to between middle of caudal peduncle and middle of caudal fin lobe. There are 51 – 61 (mean 55.1, SD 2.7) pored scales along lateral line; 8 (1), 9 (4), 10 (6) or 11 (12) scale rows above lateral line; 8 (2), 9 (12) or 10 (4) scale rows below lateral line. Coloration of preserved specimens dark greyish-brown on back, flanks yellowish grey, belly yellowish white; head, back and flanks with large brownish-black spots, irregularly grouped; on head spotting extends downwards to cheeks; all fins typically heavily dark spotted, spots typically arranged into rows on dorsal and caudal fins and into band on ventral fins; peritoneum black. Diploid chromosome number of $2n = 100$ reported for populations from the Danube River basin in Bosnia and Herzegovina (S o f r a d Ź i j a & B e r b e r o v i ć 1973), and Yugoslavia (V u j o s e v i ć et al. 1983, F i š t e r et al. 1999).



Fig. 4. *Barbus balcanicus*, NMW-94609, holotype, 130.0 mm SL; Yugoslavia: Krupaja River at Milanovac (upper caudal lobe missing).

E t y m o l o g y . Named after the Balkan Peninsula, where the species is almost exclusively, and widely distributed. An adjective.

G e o g r a p h i c a l d i s t r i b u t i o n . The mountain and submountain brooks and rivers, and less often lakes and reservoirs, in the Dinaric Mts on the Balkan Peninsula in Yugoslavia, Slovenia, and most likely also in Bosnia and Herzegovina, and Croatia (Fig. 1). The rivers draining this area are southern tributaries of the Middle Danube River, the largest being the Sava River and Velika Morava River (including Vlasinsko Jezero reservoir). It most likely inhabits also the drainage of the Drava River in Slovenia, an eastern tributary of the Middle Danube (Š u m e r & P o v ž 1998). It is known also from the Nera River and apparently lives also in the Cerna River (H e c k e l & K n e r 1858), which both are northern tributaries of the Middle Danube River in the south-eastern corner of the Carpathians in Banat, Romania. It is further known from the Archar River and Beli Vit River, the southern tributaries of the Lower Danube River in the Western Stara Planina Mts in Bulgaria. Outside the Danube River basin, populations apparently conspecific with this species are known from rivers of the Aegean Sea drainage in northern Greece: Gallikos River (M a c h o r d o m & D o a d r i o 2001), Vardar (= Axios) River (T s i g e n o p o u l o s & B e r r e b i 2000, K o t l í k & B e r r e b i 2002), and Aliakmon River (T s i g e n o p o u l o s & B e r r e b i 2000, M a c h o r d o m & D o a d r i o 2001). The latter river represents the southernmost limit of the species' known distribution. It occurs also in the northern Greek Vegoritits Lake (Z a r d o y a & D o a d r i o 1999) and most likely also in the Vardar River basin in the Republic of Macedonia (S i m o n o v i ć & N i k o l i ć 1996). The westernmost known populations of this species are located in the Isonzo (= Soča) River basin of the Adriatic Sea drainage in Italy and Slovenia (K o t l í k & B e r r e b i 2002, T s i g e n o p o u l o s et al. 2002b).

Discussion

K o t l í k & B e r r e b i (2002) recognised three distinct species, identifiable by unique mtDNA alleles, within the Danubian rheophilic barbs until now referred to under the name *B. petenyi*. A concordant divergence pattern is displayed by nuclear allozyme loci (T s i g e n o p o u l o s et al. 1999, 2002b). We show that the three species are morphologically very similar to each other but one of them (*B. balcanicus*) can be distinguished by subtle differences in the snout shape and body and fin colour pattern, as detailed in the diagnoses.

Table 2. Morphometric characteristics of *Barbus petenyi*, *B. carpathicus* and *B. balcanicus*.

	<i>Barbus petenyi</i>		<i>Barbus carpathicus</i>		<i>Barbus balcanicus</i>	
	neotype NMW- 94602	n = 13 mean \pm SD range	holotype NMW- 94604	n = 20 mean \pm SD range	holotype NMW- 94609	n = 18 mean \pm SD range
SL (mm)	135.0	122.2 \pm 11.4 110.0-143.0	110.0	151.4 \pm 23.2 110.0-186.0	130.0	136.8 \pm 16.3 114.0-174.0
In percents of SL						
Total length	119.3	117.3 \pm 3.5 107.1-120.2	117.3	115.9 \pm 2.2 111.1-120.3	113.1	115.5 \pm 1.8 111.5-118.5
Head length	24.8	23.4 \pm 1.1 20.8-24.8	24.8	24.6 \pm 0.6 23.1-25.6	24.6	24.2 \pm 1.1 22.0-26.1
Maximum body depth	21.6	21.2 \pm 1.4 19.1-23.1	21.7	20.8 \pm 1.0 18.6-22.6	26.1	21.5 \pm 1.6 18.8-26.1
Predorsal distance	51.9	48.7 \pm 2.5 43.7-51.9	48.8	49.7 \pm 1.2 46.3-52.2	50.2	49.6 \pm 2.2 45.5-54.2
Preanal distance	69.9	69.7 \pm 2.5 64.4-74.1	71.5	73.8 \pm 1.6 71.5-77.4	72.0	73.0 \pm 2.6 67.6-77.7
Preventral distance	53.6	50.7 \pm 2.1 45.9-53.6	53.1	53.2 \pm 1.2 50.7-55.3	51.2	52.4 \pm 1.8 50.2-56.6
Distance between pectoral and ventral fin bases	30.4	29.5 \pm 1.5 26.6-32.8	29.5	29.0 \pm 1.3 26.2-31.7	29.3	29.6 \pm 1.0 28.0-32.5
Distance between pectoral and anal fin bases	48.9	49.2 \pm 2.6 44.5-53.3	49.5	49.9 \pm 1.7 46.6-54.5	50.2	51.3 \pm 1.4 49.5-54.4
Length of caudal peduncle	18.1	17.9 \pm 1.1 15.8-19.2	19.5	18.3 \pm 1.1 17.0-21.4	18.9	18.3 \pm 1.4 15.9-21.2
Minimum body depth	9.3	9.6 \pm 0.4 9.0-10.4	9.5	9.0 \pm 0.6 7.5-9.8	10.5	9.5 \pm 0.8 7.9-10.9
Depth of caudal peduncle	12.9	11.5 \pm 0.7 10.5-12.9	11.7	10.8 \pm 1.0 9.0-13.6	12.0	10.5 \pm 0.7 9.3-12.0
Length of dorsal fin	12.2	12.1 \pm 0.9 10.4-13.8	12.1	13.0 \pm 0.9 10.8-14.6	12.1	11.8 \pm 0.7 10.2-12.8
Depth of anal fin	18.3	18.8 \pm 2.4 15.3-23.3	17.4	20.3 \pm 2.6 15.9-24.1	20.2	22.0 \pm 1.7 19.7-24.9
Length of anal fin base	6.4	6.7 \pm 0.8 4.9-7.9	7.5	7.7 \pm 0.5 6.9-8.8	7.2	7.6 \pm 0.9 6.1-8.9
Length of ventral fin base	15.4	14.4 \pm 0.8 13.1-15.4	14.9	13.9 \pm 0.8 12.6-15.9	13.7	13.9 \pm 0.8 12.0-15.5
Length of pectoral fin base	18.5	18.2 \pm 0.8 16.3-19.3	17.6	17.3 \pm 0.9 16.0-19.1	16.6	16.9 \pm 1.4 13.0-19.2
Length of upper caudal lobe	23.7	22.1 \pm 2.0 18.4-24.7	23.2	21.0 \pm 1.0 19.4-23.2		20.0 \pm 1.7 16.9-23.1

Table 2. Continued.

	<i>Barbus petenyi</i>		<i>Barbus carpathicus</i>		<i>Barbus balcanicus</i>	
	neotype NMW- 94602	n = 13 mean ± SD range	holotype NMW- 94604	n = 20 mean ± SD range	holotype NMW- 94609	n = 18 mean ± SD range
Length of middle caudal part	10.2	9.0 ± 0.9 7.1-10.3	10.3	8.4 ± 0.8 6.9-10.3	8.4	8.2 ± 0.9 6.4-10.2
Length of lower caudal lobe	23.5	22.0 ± 2.0 17.9-24.4	23.2	19.4 ± 1.6 16.5-23.2	18.7	18.8 ± 1.5 16.8-23.1
Body width	13.8	12.7 ± 1.4 10.9-15.4	14.3	12.5 ± 1.2 9.9-15.0	14.4	14.2 ± 2.1 11.1-17.5
Head width	14.8	14.5 ± 1.3 12.6-17.7	14.0	13.9 ± 0.7 12.5-14.9	15.2	14.4 ± 1.7 11.9-16.9
Preorbital distance	11.0	9.9 ± 0.7 8.8-11.0	11.1	11.4 ± 0.5 10.3-12.4	9.4	10.5 ± 0.9 8.5-11.8
Postorbital distance	11.0	10.6 ± 0.5 9.6-11.4	9.9	10.3 ± 0.4 9.8-11.3	10.7	10.5 ± 0.6 9.4-11.7
Horizontal eye diameter	4.9	4.1 ± 0.5 3.2-4.9	4.7	3.8 ± 0.4 3.1-4.7	4.3	3.9 ± 0.4 3.1-4.6
Interorbital distance	6.4	6.7 ± 0.5 6.0-7.5	7.0	7.2 ± 0.5 6.4-8.3	7.2	7.2 ± 0.5 6.1-8.0
Length of anterior barbel	3.6	3.4 ± 0.5 2.6-4.5	2.8	3.8 ± 0.6 2.8-5.0	3.3	4.0 ± 0.7 2.7-5.3
Length of posterior barbel	4.5	4.9 ± 0.7 3.9-6.3		5.6 ± 0.8 4.2-7.5	5.2	5.9 ± 1.1 3.9-7.9
Head depth	15.2	14.1 ± 0.7 13.3-15.4	14.7	14.2 ± 0.5 13.5-14.7	16.6	15.4 ± 0.7 14.2-16.8

The species have adjacent, mutually exclusive geographical distributions (Fig. 1) centred in the Danube River basin in the Southern Carpathians and the Stara Planina Mts (*B. petenyi*), the Western Carpathians (*B. carpathicus*), and the Dinaric Mts (*B. balcanicus*). No geographic overlap is evident from the genetic data except a single site (Beli Vit River) in the Stara Planina Mts where the alleles of *B. petenyi* as well as of *B. balcanicus* have been observed, indicating absence of the effective gene flow among the three species (K o t l í k & B e r r e b i 2002).

Phylogenetic reconstructions based on mtDNA showed each of the Danubian rheophilic species as a lineage clearly distinct from other *Barbus* but did not place the three species together in a monophyletic group (T s i g e n o p o u l o s & B e r r e b i 2000, M a c h o r d o m & D o a d r i o 2001, K o t l í k & B e r r e b i 2002, T s i g e n o p o u l o s et al. 2002b). *Barbus carpathicus* is likely the sister species of *B. balcanicus*, their closest phylogenetic relatives being *B. caninus* Bonaparte, 1839 (from northern Italy) and *B. meridionalis*. *Barbus petenyi* shows, however, a close relationship to *B. prespensis* Karaman, 1924 (from the Prespa Lake and its tributaries in Albania, Greece and the Republic of Macedonia) and

B. rebeli Koller, 1926 (from Albania and northwestern Greece), with which it forms a monophyletic group (Tsigenopoulos & Berrebi 2000, Machordom & Doadrio 2001, Kotlík & Berrebi 2002).

The taxonomic recognition of three species of the Danubian rheophilic barbs poses a nomenclatural problem. The localities “Szamos [= Someş River], Maros [= Mureş River], Aluta [= Olt River] in Siebenbürgen [= Transylvania]” listed by Heckel (1852) with the very brief and vague diagnosis of *B. petenyi* include ranges of two species (*B. carpathicus* and *B. petenyi*; Fig. 1). Bănărescu (1957) considered the Mureş River as the type locality of *B. petenyi*, which later authors interpreted as the type-locality restriction (Oliva & Chitravadivelu 1972, Kottelat 1997). However, as noted by Dubois & Ohler (1994, 1996) the definitive restriction of the type locality can be only through a lectotype or neotype designation (ICZN 1999, Art. 76), an act not pursued by Bănărescu (1957).

No name-bearing type was fixed for *B. petenyi* in the original description by Heckel (1852). Kottelat (1997) regarded 28 specimens, kept in NMW under the name *B. petenyi* and acquired before 1852, as “tentative syntypes”. We checked the associated museum records and found no evidence for the type status of any of these specimens. Although signed (or co-signed) by Heckel, the acquisition records do not identify any specimen as type, and no specimen was assigned to *B. petenyi* when acquired. Only later has this name been added to the records, probably by Heckel himself (as tentatively judged from the handwriting). Furthermore, only 12 of these specimens originated from “Siebenbürgen”, without more precise specification (NMW 5318–5324:1 and 2, 54442:1 and 2, and 10875–10876; acquired in 1847, donated by Kotschy). We therefore conclude that it is impossible to ascertain the identity of the original name-bearing type of *B. petenyi* Heckel, 1852.

This situation means a threat to the nomenclatural stability and qualifies *B. petenyi* for a neotype designation (ICZN 1999, Art. 75.3). To stabilize the taxonomic status of this species, and not to upset the Bănărescu’s (1957) invalid nomenclatural act (ICZN 1999, Recommendation 74A), we hereby formally designate as the neotype for *B. petenyi* Heckel, 1852 the specimen NMW–94602 from the Mureş River at Răstoliţa in Transylvania, Romania. Therefore, the name *B. petenyi* is definitively attached to the species from the Southern Carpathians and the Stara Planina Mts. The neotype is illustrated in Fig. 2, and the sequence of its mtDNA allele and its morphometric characteristics are given in Tables 1 and 2, respectively.

Another two names are available for the Danubian rheophilic barbs, neither of which can be used as valid, however. We have therefore coined the new name *B. carpathicus* for the species from the Western Carpathians and *B. balcanicus* for that from the Dinaric Mts.

The name *Pseudobarbus Leonhardi* established by Bielez (1853) was expressly proposed as a new name to replace *B. petenyi* Heckel, 1852. It is therefore a new replacement name for and a junior objective synonym of *B. petenyi* Heckel, 1852 (ICZN 1999, Art. 72.7).

From the Upper Vistula River basin in Poland, from within the distribution of *B. carpathicus*, Rolik (1970) described subspecies *B. cyclolepis waleckii* of *B. cyclolepis* Heckel, 1837, a species from southeastern Balkans and Anatolia. Rolik (1970) assumed that, because of the intermediate morphology of this subspecies, earlier authors erroneously identified it as hybrids between *B. barbatus* (Linnaeus, 1758) and *B. carpathicus* (therein

referred to as *B. petenyi*; Rolik 1967b, 1970). We investigated the mtDNA of two specimens from the type locality with the morphological characteristics of *B. cyclolepis waleckii* (A. Boroń, personal communication) and showed that one fish carried a *B. barbuis* allele while the other possessed an allele of *B. carpathicus* (unpubl. obs.). We consider this a strong indication that they were hybrids rather than representatives of a distinct evolutionary lineage. The natural hybrids between *B. barbuis* and *B. carpathicus* have been repeatedly reported from sympatric localities (e.g. Kux & Weisz 1964; Krupka & Holčík 1976; Stratil et al. 1983; Šlechtová et al. 1993). As a name established for individuals now realized to be hybrids, *B. cyclolepis waleckii* Rolik, 1970 cannot be used as the valid name for *B. carpathicus* (ICZN 1999, Art. 23.8).

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LITERATURE

- BĂNĂRESCU, P., 1957: Die rassiale Zugehörigkeit einiger rumänischen Süßwasser-Fischarten. *Izd. Inst. Piscicult. R. P. Macedonia*, 2: 59–80.
- BĂNĂRESCU, P., 1964: Fauna Republicii Populare Române [Fauna of the People's Republic of Romania Vol. 13]. Pisces – Osteichthyes. *Acad. Rep. Pop. Romine, Bucuresti (in Romanian)*.
- BĂNĂRESCU, P., 1991: Zoogeography of fresh waters, Volume 2: distribution and dispersal of fresh water animals in North America and Eurasia. *AULA-Verlag, Wiesbaden*.
- BENSON, D. A., KARSCH-MIZRACHI, I., LIPMAN, D. J., OSTELL, J., RAPP, B. A. & WHEELER, D. L., 2000: GenBank. *Nucleic Acids Res.*, 28: 15–18.
- BERG, L. C., 1949: Ryby presnykh vod SSSR i sopredelnykh stran (Freshwater fishes of the USSR and adjacent countries). Vol. 2. *Izd. Akad. Nauk SSSR, Moscow, Leningrad (in Russian, translation to English: Israel Program for Scientific Translations, Jerusalem, 1965)*.
- BERREBI, P., 1995: Speciation of the genus *Barbus* in the North Mediterranean Basin: recent advances from biochemical genetics. *Biological Conservation*, 72: 237–249.
- BERREBI, P., KOTTELAT, M., SKELTON, P. & RÁB, P., 1996: Systematics of *Barbus*: state of the art and heuristic comments. *Folia Zool.*, 45(Suppl. 1): 5–12.
- BIELZ, E. A., 1853: Ueberzicht der lebenden Fische Siebenbürgens. *Verh. Mitt. Siebenbürgischen Ver. Naturwiss. Hermannstadt*, 4: 172–185.
- BOROŃ, A., 2000: Brzanka *Barbus peloponnesius*. In: Brylińska, M. (ed.), Ryby stodkowodne Polski [Freshwater fishes of Poland]. *Wydawnictwo Naukowe PWN, Warszawa*: 183–186 (in Polish).
- DOADRIO, I., 1990: Phylogenetic relationships and classification of western palearctic species of the genus *Barbus* (Osteichthyes, Cyprinidae). *Aquatic Living Resources* 3: 265–282.
- DUBOIS, A. & OHLER, A., 1994: Frogs of the subgenus *Pelophylax* (Amphibia, Anura, genus *Rana*): A catalogue of available and valid scientific names, complete synonymies, proposed common names, and maps showing all type localities. *Zool. Polon.*, 39: 139–204.
- DUBOIS, A. & OHLER, A., 1996: Early scientific names of Amphibia Anura I. Introduction. *Bull. Mus. natl. Hist. nat.*, 4^e sér., A, 18: 287–320.

- FIŠTER, S., CAKIĆ, P. & KATARANOVSKI, D., 1999: Karyotype analysis of *Barbus barbus* L. and *Barbus peloponnesius* V. (Cyprinidae) and frequencies of breaks and gap-type structural chromosome changes in fishes from the river Vapa. *Acta Veterinaria-Beograd*, 49: 385–392.
- HARKA, Á., 1997: Halaink. Képes határozó és elterjedési útmutató [Determination key and distribution of fishes]. *Természet – és Környezetvédő Tanárok Egysülete, Budapest (in Hungarian)*.
- HECKEL, J., 1848: Über die Fische Ungarns. *Ber. Mitt. Freund. Naturwiss. Wien*, 3: 194–195.
- HECKEL, J., 1852: Verzeichniss der Fische des Donnaugebietes in der ganzen Ausdehnung des österreichischen Kaiserstaates. *Verh. Zool. Bot. Ges. Wien*, 2: 28–33.
- HECKEL, J. & KNER, R., 1858: Die Süßwasserfische der Österreichischen Monarchie mit Rücksicht auf der angrenzenden Länder. *Verlag von Wilhelm Engelmann, Leipzig*.
- HOLČÍK, J., 1989: Determination criteria. In: Holčík, J.(ed.), *The freshwater fishes of Europe*. Vol. 1, Part II. General introduction to fishes. Acipenseriformes. *Aula-Verlag, Wiesbaden*: 38–58.
- ICZN (International Commission on Zoological Nomenclature), 1999: International Code of Zoological Nomenclature. *International Trust for Zoological Nomenclature, London*, 4th ed.
- KARAKOUSIS, Y., MACHORDOM, A., DOADRIO, I. & ECONOMIDIS, P. S., 1995: Phylogenetic relationships of *Barbus peloponnesius* Valenciennes, 1842 (Osteichthyes: Cyprinidae) from Greece and other species of *Barbus* as revealed by allozyme electrophoresis. *Biochem. Syst. Ecol.*, 23: 364–375.
- KARAKOUSIS, Y., PEIOS, C., ECONOMIDIS, P. S. & TRIANTAFYLIDIS, C., 1993: Multivariate analysis of the morphological variability among *Barbus peloponnesius*, (Cyprinidae) populations from Greece and two populations of *B. meridionalis meridionalis* and *B. meridionalis petenyi*. *Cybiurn*, 17: 229–240.
- KARAMAN, S. M., 1971: Süßwasserfische der Türkei. 8. Teil: Revision der Barben Europas, Vorderasien und Nordafrikas. *Mitt. Hamburg. Zool. Mus. Inst.*, 67: 175–254.
- KOTLÍK, P. & BERREBI, P., 2002: Genetic subdivision and biogeography of the Danubian rheophilic barb *Barbus petenyi* inferred from phylogenetic analysis of mitochondrial DNA variation. *Mol. Phylogenet. Evol.*, 24: 10–18.
- KOTTELAT, M., 1997: European freshwater fishes. An heuristic checklist of the freshwater fishes of Europe (exclusive of former USSR), with an introduction for non-systematists and comments on nomenclature and conservation. *Biologia, Bratislava*, 52: 1–271.
- KRUPKA, I. & HOLČÍK, J., 1976: On the occurrence of *Barbus plebejus* in the Poprad river (Vistula basin, Czechoslovakia) with regard to its assumed hybrid origin. *Věst. Čs. Společ. Zool.*, 40: 163–178.
- KUX, Z., 1964: Ichthyofauna západní části karpatského oblouku a přilehlých nížin [Ichthyofauna of western part of the Carpathian range and adjacent lowlands]. *PhD Thesis, Institute of Vertebrate Research, Czechoslovakian Academy of Sciences, Brno (in Czech)*.
- KUX, Z. & WEISZ, T., 1964: Ein Beitrag zur Kenntnis der Ichthyofauna der slowakischen Flüsse. *Acta Musei Moraviae*, 49: 191–246 (in Czech, with a summary in German).
- MACHORDOM, A. & DOADRIO, I., 2001: Evolutionary history and speciation modes in the cyprinid genus *Barbus*. *Proc. R. Soc. Lond. (Biol.)*, 268: 1297–1306.
- OLIVA, O. & CHITRAVADIVELU, K., 1972: A note on the systematics of *Barbus meridionalis petenyi* Heckel, 1847 (Osteichthyes : Cyprinidae) from Poland with discussion on allied forms. *Věst. Čs. Společ. Zool.*, 36: 258–266.
- RÁB, P., OZOUF-COSTAZ, C. & BERREBI, P., 1993: Karyotypes, distribution of centromeric heterochromatin and polymorphism of NORS in *Barbus meridionalis* from Southern France and Eastern Slovakia: preliminary results. *Cahiers d'Ethologie*, 13: 195–198.
- REMBISZEWSKI, J. M. & ROLIK, H., 1975: Katalog Fauny Polski [A checklist of the freshwater fishes of Poland]. *Panstwowe Wydawnictwo Naukowe, Warszawa (in Polish)*.
- ROLIK, H., 1967a: Materiały do ichtiofauny Strwiąza (dopływ Dniestru) ze szczególnym uwzględnieniem *Gobio gobio* (L.) i *Cobitis (Sabanajewia) aurata* (Fil.) [Information on the ichthyofauna of the Strwiąz (a Dniester tributary) with special regards to *Gobio gobio* (L.) and *Cobitis (Sabanajewia) aurata* (Fil.)]. *Fragm. Faun.*, 14: 133–151 (in Polish).
- ROLIK, H., 1967b: O niektórych naturalnych krzyżówkach ryb karpiowatych (Pisces, Cyprinidae) w Polsce (On some natural hybrids of cyprinid fishes (Pisces, Cyprinidae) in Poland). *Fragm. Faun.*, 14: 153–167 (in Polish, with summaries in Russian and German).
- ROLIK, H., 1970: *Barbus cyclolepis waleckii* ssp. n. – A new subspecies of *B. cyclolepis* Haeckel, 1840, from the Vistula and Dniestr Basins (Pisces, Cyprinidae). *Bull. Acad. Pol. Sci., Cl. II. Vol. XVIII Ser. Sci. Biol.*: 401–404.
- SIMONOVIĆ, P. D. & NIKOLIĆ, V. P., 1996: Freshwater fish of Serbia: An annotated checklist with some faunistic and zoogeographical considerations. *Bios (Macedonia, Greece)*, 4: 137–156.

- ŠLECHTOVÁ, V., ŠLECHTA, V. & BERREBI, P., 1993: Diversité génétique du genre *Barbus* dans les rivières tchèques et slovaques. Résultats préliminaires. *Cahiers d'Ethologie*, 13: 207–210.
- SOFRADŽIJA, S. & BERBEROVIĆ, L., 1973: The chromosome number of *Barbus meridionalis petenyi* Heckel (Cyprinidae, Pisces). *Bull.Sci.-Conseil Acad. Sci. Arts RSF Yugoslavia*, 8: 77–78.
- STARMACH, K. & ROSÓL, E., 1961: Morphometric characteristics of *Barbus petenyi* Heckel from the upper region of Wisła (Vistula). *Acta Hydrobiol.*, 3: 217–224.
- STEINDACHNER, F., 1882: Ichthyologische Beiträge (XII). *Sitzber. Math.-Naturwiss. Cl. kais. Akad. Wiss. Wien*, 86: 61–82.
- STRATIL, A., BOBÁK, P., TOMÁŠEK, V. & VALENTA, M., 1983: Transferrins of *Barbus barbus*, *Barbus meridionalis petenyi* and their hybrids. Genetic polymorphism, heterogeneity and partial characterisation. *Comp. Biochem. Physiol.*, 76B: 845–850.
- ŠUMER, S. & POVŽ, M., 1998: Present knowledge on the distribution of the species from the genus *Barbus* in Slovenia and on age and growth of *Barbus peloponnesius petenyi* (Cyprinidae). *Folia Zool.*, 47(Suppl. 1): 73–79.
- TSIGENOPOULOS, C. S. & BERREBI, P., 2000: Molecular phylogeny of North Mediterranean freshwater barbs (genus *Barbus*: Cyprinidae) inferred from cytochrome *b* sequences: biogeographic and systematic implications. *Mol. Phylogenet. Evol.*, 14: 165–179.
- TSIGENOPOULOS, C. S., KARAKOUSIS, Y. & BERREBI, P., 1999: The North Mediterranean *Barbus* lineage: phylogenetic hypotheses and taxonomic implications based on allozyme data. *J. Fish Biol.*, 54: 267–286.
- TSIGENOPOULOS, C. S., RÁB, P., NARAN, D. & BERREBI, P., 2002a: Multiple origins of polyploidy in the phylogeny of southern African barbs (Cyprinidae) as inferred from mtDNA markers. *Heredity*, 88: 466–473.
- TSIGENOPOULOS, C. S., KOTLÍK, P. & BERREBI, P., 2002b: Biogeography and pattern of gene flow among *Barbus* species (Teleostei: Cyprinidae) inhabiting the Italian Peninsula and neighbouring Adriatic drainages as revealed by allozyme and mitochondrial sequence data. *Biol. J. Linnean Soc.*, 75: 83–99.
- VALENTA, M., RÁB, P., STRATIL, A., KÁLAL, L. & OLIVA, O., 1979: Karyotypes, heterogeneity and polymorphism of proteins in the tetraploid species *Barbus meridionalis* and its hybrids with *Barbus barbus*. In: Pavlitchenko, V. P. (ed.), *Proc. XVIth Anim. Blood Groups Biochem. Polymorph.*, IV: 204–214.
- VUJOSEVIĆ, M., ŽIVKOVIĆ, S., RIMSA, D., JURISIĆ, S. & ČAKIĆ, P., 1983: The chromosomes of 9 fish from Danub basin in Yugoslavia. *Acta Biol. Jug.-Ichthyologia*, 15: 29–40.
- ZARDOYA, R. & DOADRIO, I., 1999: Molecular evidence on the evolutionary and biogeographical patterns of European cyprinids. *J. Mol. Evol.*, 49: 227–237.
- ZAUNER, G., 1998: Der Semling – eine verschollene Fischart wurde wiederentdeckt. *Österreichs Fischerei*, 51(10): 218.