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Original Article

Capoeta baliki Turan, Kottelat, Ekmekçi & Imamoglu, 2006 a junior synonym of *Capoeta tinca* (Heckel, 1843) (Teleostei: Cyprinidae)

Erdoğan Çiçek[*1], Soheil Eagderi[2], Sevil Sungur[3], Burak Secer[1]

[1]Department of Biology, Faculty of Art and Sciences, Nevşehir Hacı Bektaş Veli University, Nevşehir, Turkey.
[2]Department of Fisheries, Faculty of Natural Resources, University of Tehran, Karaj, Iran.
[3]Health Services Vocational School, Nevşehir Hacı Bektaş Veli University, 50300, Nevşehir, Turkey.

Abstract: *Capoeta baliki* was described from Sakarya basin, Turkey. It was distinguished from its nearest congener i.e. *C. tinca* based on a combination of characters, including fewer serrae along posterior margin of last simple dorsal-fin ray, modally fewer scale rows between lateral line and dorsal-fin origin, fewer vertebrae, deeper and shorter head and slenderer caudal peduncle. We examined the synonymy hypothesis of *C. baliki* and *C. tinca* by comparing their morphometric, meristic and molecular characters. Based on the results, their morphometric and meristic characters largely overlapped and no character was found to distinguish them. In addition, a low K2P mean genetic divergence of 0.37% *C. baliki* and *C. tinca* based on cyt*b* gene and clustering in same clad showed that they are identical in molecular characters. As no character could be found to clearly distinguish these species, we treat *C. baliki* as a junior synonym of *C. tinca*.

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Introduction

Capoeta tinca Heckel (1843), described from Nilüfer River, Bursa Province, Susurluk basin of Turkey, is found throughout the Black Sea watersheds, as well as Sakarya and Kizilirmak basins in the central Anatolia (Geldiay and Balık, 2007; Çiçek at al., 2020). Turan et al. (2006) described the *C. tinca* populations of the central Anatolian basins i.e. Sakarya and Kizilirmak as a distinct species of *C. baliki* based on some morphological characters. However, further works (Özdemir, 2013, 2015; Kaya, 2019) rejected distinguishing characters of *C. baliki* from *C. tinca* suggesting *C. baliki* as a junior synonym of *C. tinca*. Additionally, pronounced discriminative differences was not found in the osteological characteristics of *C. baliki* and *C. tinca* (Küçük et al., 2008).

In recent years, molecular studies (Özdemir, 2013; Bektaş et al., 2017, 2019; Ghanavi et al., 2016; Levin, 2012; Zareian and Esmaeili, 2017; Zareian et al., 2018) based on both COI and *cytb* genes of mitochondrion indicated clustering of *C. tinca* and *C. baliki* in the same clade supporting *C. baliki* as junior synonym of *C. tinca*. Hence in the present study, we decided to examine the synonymy hypothesis of *C. baliki* and *C. tinca* by comparing their morphometric, meristic and molecular (mtDNA *cytb* gene) characters.

Materials and Methods

Specimens of *C. tinca* were collected from its type locality (Susurluk basin) and *C. baliki* from Sakarya basins. All specimens caught by electrofishing, and after anaesthesia by MS222, they were fixed into 5% buffered formaldehyde and stored in 70% ethanol after two weeks. Methods for counts and measurements followed Armbruster (2012). Measurements were made with a dial calliper to the nearest 0.1 mm. Gill rakers were counted on the outer margin of the anterior gill arch. The posterior pair of the branched rays articulating on a single pterygiophore in the dorsal and anal fins were noted as "1½".

Twenty morphometric characters were measured (Table 1) and then standardized using an allometric method to remove size-dependent variation using M_{adj}

*Correspondence: Erdoğan Çiçek
E-mail: erdogancicek@nevsehir.edu.tr
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Table 1. Cytochrome b sequences downloaded from NCBI GenBank with information on basin, country of origin and reference.

Species	Drainage	Country	Published by	Genbank Acc. No.
Capoeta baliki	Black Sea basin, Sakarya	Turkey	Bektas et al. 2017	GQ424019
Capoeta baliki	Black Sea basin, Sakarya	Turkey	Bektas et al. 2017	GQ424016
Capoeta baliki	Black Sea basin, Sakarya	Turkey	Bektas et al. 2017	GQ424015
Capoeta baliki	Black Sea basin, Sakarya	Turkey	Bektas et al. 2017	GQ424014
Capoeta baliki	Black Sea Basin, Sakarya	Turkey	Bektas et al. 2017	GQ424013
Capoeta baliki	Black Sea basin, Sakarya	Turkey	Bektas et al. 2017	GQ424012
Capoeta baliki	Black Sea basin, Sakarya	Turkey	Bektas et al. 2017	GQ424011
Capoeta baliki	Lake Iznik basin, Çakirca Stream	Turkey	Levin et al. 2012	JF798275
Capoeta baliki	Sakarya basin, Kurtbogazı Dam Lake	Turkey	Levin et al. 2012	JF798274
Capoeta baliki	Sakarya basin, Kurtbogazı Dam Lake	Turkey	Levin et al. 2012	JF798273
Capoeta baliki	Black Sea Basin, Kelkit River	Turkey	Levin et al. 2012	JF798272
Capoeta baliki	Black Sea Basin, Kızılırmak River	Turkey	Levin et al. 2012	JF798271
Capoeta tinca	Eber Lake Basin, Afyon	Turkey	Bektas et al. 2017	GQ424010
Capoeta tinca	Eber Lake Basin, Afyon	Turkey	Bektas et al. 2017	GQ424009
Capoeta tinca	Marmara Basin, Susurluk	Turkey	Bektas et al. 2017	GQ424008
Capoeta tinca	Marmara Basin, Susurluk	Turkey	Bektas et al. 2017	GQ424007
Capoeta tinca	Marmara Basin, Susurluk	Turkey	Bektas et al. 2017	GQ424006
Capoeta tinca	Marmara Basin, Susurluk	Turkey	Bektas et al. 2017	GQ424005
Capoeta tinca	Marmara Basin, Susurluk	Turkey	Bektas et al. 2017	GQ424004
Capoeta damascina	Mediterranean Sea basin, Orontes River	Turkey	Levin et al. 2012	JF798306
Capoeta damascina	Mediterranean Sea basin, Orontes River	Turkey	Levin et al. 2012	JF798305
Capoeta aydinensis	Aegean Sea Basin, B. Menderes	Turkey	Bektas et al. 2017	KY065274
Capoeta aydinensis	Aegean Sea Basin, B. Menderes	Turkey	Bektas et al. 2017	KY065275
Capoeta caelestis	Mediterranean Sea basin, Kargi Stream	Turkey	Levin et al. 2012	JF798287
Capoeta caelestis	Mediterranean Sea basin, Kargi Stream	Turkey	Levin et al. 2012	JF798288
Capoeta antalyensis	Mediterranean Sea Basin, Aksu at Gokdere	Turkey	Bektas et al. 2017	GQ424021
Capoeta antalyensis	Mediterranean Sea Basin, Aksu at Gokdere	Turkey	Bektas et al. 2017	GQ424023
Capoeta sieboldii	Black Sea Basin, Kelkit River	Turkey	Levin et al. 2012	JF798330
Capoeta sieboldii	Black Sea Basin, Kızılırmak River	Turkey	Levin et al. 2012	JF798329
Capoeta sieboldii	Black Sea Basin, Kizilirmak	Turkey	Bektas et al. 2017	KY065259
Capoeta sieboldii	Black Sea Basin, Kizilirmak	Turkey	Bektas et al. 2017	KY065258
Capoeta sieboldii	Black Sea Basin, Yesilirmak	Turkey	Bektas et al. 2017	KY065256
Capoeta bergamae	Marmara Basin, Bakacak stream	Turkey	Levin et al. 2012	JF798282
Capoeta bergamae	Bakırçay River	Turkey	Levin et al. 2012	JF798280
Capoeta banarescui	Black Sea Basin, Coruh	Turkey	Bektas et al. 2017	GQ423988
Capoeta banarescui	Black Sea Basin, Coruh	Turkey	Bektas et al. 2017	GQ423984
Capoeta banarescui	Black Sea Basin, Coruh	Turkey	Bektas et al. 2017	GQ423992
Capoeta banarescui	Black Sea Basin, Coruh	Turkey	Bektas et al. 2017	GQ423991
Capoeta banarescui	Black Sea Basin, Coruh	Turkey	Bektas et al. 2017	GQ423990
Capoeta banarescui	Black Sea Basin, Coruh	Turkey	Bektas et al. 2017	GQ423989
Capoeta capoeta	Caspian Sea basin, Aras River	Iran	Ghanavi et al. 2016	KU167938
Capoeta trutta	Karoun River Drainage, Lordegan	Iran	Ghanavi et al. 2016	KM459673
Luciobarbus esocinus	Tigris River	Turkey	Yang et al. 2015	KP712264

= M $(L_s / L_0)^b$, where M is the original measurement, M_{adj} the size adjusted measurement, L_0 the standard length of the fish, L_s the overall mean of the standard length for all fish from all samples in each analysis, and *b* was estimated for each character from the observed data as the slope of the regression of log M on log L_0 using all fish in any group (Elliot, 1999). The results derived from the allometric method were confirmed by testing significance of the correlation between transformed variables and standard length (Buj et al., 2008). The morphometric data of the two species were analyzed using multivariate analyzes of

Figure 1. Lateral view of (A) *Capoeta baliki*, NUIC-1816, 106.3 mm SL; Derecik Stream, Ankara province, and (B) *C. tinca*, NUIC-1717, 119.2 mm SL Değirmen Stream, Balıkesir province (all from Turkey).

principal component analysis (PCA) and *P*-value obtained from permutation test of one-way NPMANOVA. All outliers were removed from further analysis. All analyses were performed using PAST software.

Molecular data analysis: For this study, we retrieved 43 *cytb* sequences of the published *Capoeta* from GenBank using the (BLASTn) basic local alignment search tool (Altschul et al., 1990) (Table 1). For phylogenetic reconstruction, the datasets were analysed by Bayesian Inference (BI) using MrBayes 3.1.2 (Ronquist et al., 2011) and the maximum likelihood (ML) method in IQ-TREE 1.6.0 (Nguyen et al., 2015). We determined the best-fit model of molecular evolution for the genomic dataset using the Bayesian information criterion (BIC) in IQTREE 1.6.0 (Kalyaanamoorthy et al., 2017). MrBayes was run with 6 substitution types (nst=6) and considered the gamma-distributed rate variation across sites plus a proportion of invariable sites (GTR) for the COI datasets. For BI, Bayesian inference was calculated with MrBayes v.3.2.6 (Ronquist et al., 2011). Two simultaneous analyses were run with each 2,000,000 generations and four MCMC chains sampling every 10,000 generations. Convergence was checked on Tracer 1.6 (Rambaut and Drummond, 2013). After discarding the first 10% of generations as burn-in, we obtained the 50% majority rule consensus tree and the posterior probabilities. For ML analyses, we conducted heuristic searches (1,000 runs) under a TN+F+G4 model. Uncorrected pairwise genetic distances (p-distances) were investigated based on Kimura two-parameter (K2P) distances (Tamura et al., 2013). *Capoeta capoeta* (KU167938), *Capoeta trutta* (KM459673) and *Luciobarbus esocinus* (KP712264) were used as outgroups.

Abbreviations used. HL, Head length; SL, standard length; K2P, Kimura 2-parameter. Collection codes: NUIC, Ichthyological Collection of the Nevsehir Haci Bektas Veli University.

Results

General appearances of *C. tinca* and *C. baliki* are presented in Figure 1 showing their body shapes and colour patterns similarity. Tables 2 and 3 represent their morphometric measurements and meristic counts, respectively. All morphometric and meristic features of *C. baliki* are largely overlapped with those of *C. tinca*. We failed to find any non-overlapping morphological differences between the *C. tinca* and

Table 2. Morphometric data of *Capoeta tinca* (n=20) and *C. baliki* populations (n=20).

Morphometric characters	*Capoeta tinca* (NUIC-1717)		*Capoeta baliki* (NUIC-1816)	
	min-max	**mean±SD**	**min-max**	**mean±SD**
Standard length (mm)	90.6-140.7	117.0±15.2	90.8-227.3	127.4±37.2
In percent of standard length				
Head length	23.4-24.9	24.3±0.5	21.4-26.4	24.2±1.3
Body depth at dorsal fin origin	22.9-26.3	24.5±1.1	20.2-24.8	23.1±1.4
Predorsal length	47.0-53.2	49.6±2.1	46.7-53.8	50.9±1.9
Prepelvic length	51.2-54.4	52.5±1.1	49.8-54.9	52.8±1.5
Preanal length	72.9-76.0	74.7±1.1	73.5-78.1	75.0±1.6
Distance between pectoral-fin origin to anal fin	51.1-55.7	53.9±1.5	43.3-58.1	52.7±3.5
Distance between pectoral-fin origin to pelvic fin	29.1-32.9	31.1±1.2	29.7-34.2	31.1±1.3
Distance between pelvic-fin origin to anal fin	21.1-23.9	22.6±0.9	20.2-24.2	22.3±1.0
Dorsal-fin height	19.3-22.8	21.4±1.1	18.1-22.7	20.4±1.5
Anal-fin length	16.0-18.4	16.9±0.9	16.0-22.2	18.3±2.1
Pectoral-fin length	17.6-19.7	18.7±0.7	17.3-19.6	18.6±0.8
Pelvic-fin length	15.0-16.6	15.8±0.6	14.7-17.1	15.7±0.7
Upper caudal-fin lobe	16.9-25.3	22.7±2.2	18.1-23.6	21.6±1.4
Length of caudal peduncle	17.6-19.3	18.6±0.7	16.3-20.3	18.0±1.4
Depth of caudal peduncle	11.5-12.8	12.1±0.4	10.9-12.9	12.2±0.6
In percent of Head length				
Head depth at eye	45.2-51.0	48.4±1.7	48.0-55.2	50.9±2.2
Snout length	32.4-38.2	35.2±1.4	35.3-40.4	37.5±1.6
Eye horizontal diameter	17.1-22.5	19.8±1.5	16.6-22.1	19.0±1.8
Interorbital width	37.5-42.0	39.9±1.7	37.4-44.2	41.1±2.0
Postorbital distance	46.2-51.2	48.8±1.8	46.2-52.3	49.1±1.7
Maximum head width	60.2-68.3	62.9±2.5	60.5-69.2	63.7±2.8

Table 3. Meristic data of *Capoeta tinca* (NUIC-1717) and *C. baliki* (NUIC-1816) (n=20 in each populations).

	Gill raker					
Examined materials	**19**	**20**	**21**	**22**	**23**	**24**
Capoeta tinca	3	6		10		1
Capoeta baliki	2	5	3	8	1	1

	Lateral Line Scales					
Examined materials	**75**	**76**	**77**	**78**	**79**	**80**
Capoeta tinca	8		4			3
Capoeta baliki	12	5			3	

	Scales above lateral line					**Scales below lateral line**		
Examined materials	**14**	**15**	**16**	**17**	**18**	**7**	**8**	**9**
Capoeta tinca	1	15	4			1	14	5
Capoeta baliki	1	12	6	1			18	2

	Branched dorsal-fin rays			
Examined materials	**7½**	**8½**	**9½**	**mode**
Capoeta tinca		4	16	9
Capoeta baliki		2	18	9

	Branched anal-fin rays			
Examined materials	**5**	**6**	**7**	**mode**
Capoeta tinca	2	18		6
Capoeta baliki	4	16		6

	Pelvic-fin rays			
Examined materials	**7**	**8**	**9**	**mode**
Capoeta tinca	2	18		8
Capoeta baliki		20		8

	Pectoral-fin rays				
Examined materials	**17**	**18**	**19**	**20**	**mode**
Capoeta tinca	2	16		2	18
Capoeta baliki		18		2	18

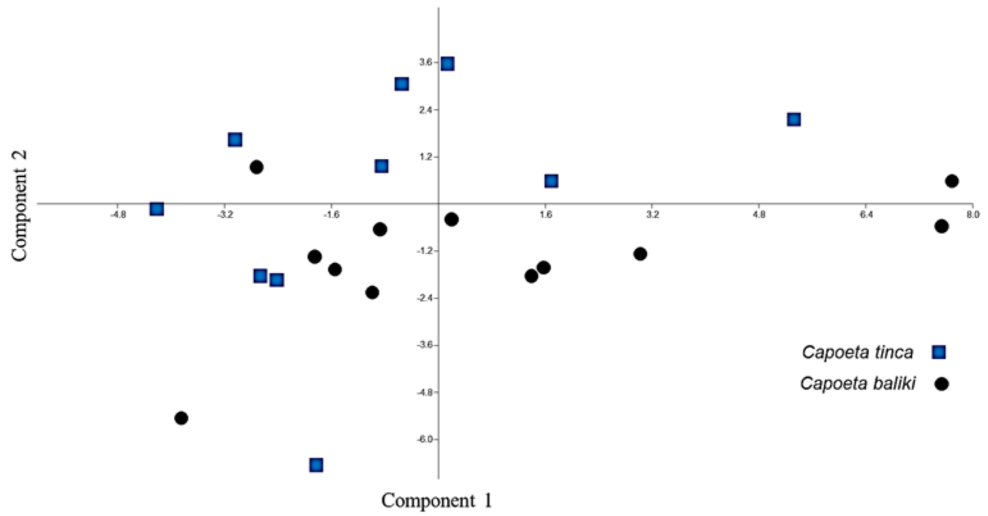

Figure 2. The PCA graph of morphometric characters in *Capoeta tinca* (NUIC-1717, n=10) and *C. baliki* (NUIC-1816, n=12).

C. baliki.

In PCA, the first three PCs accounted a total of 84.49% of the variances (PC1=41.02, PC2=20.90 and PC3=12.857) (Jolliffe cut-off=1.119). By plotting the first two PCs, the distribution of the studied species based on their morphometrics are presented in Figure 2, showing overlapping the specimens of both *C. tinca* and *C. baliki*. The result of multivariate one-way NPMANOVA showed no different between two species (P=0.1003, F=1.913).

Based on Figure 3, *Capoeta* species, including *C. tinca*, *C. baliki, C. banarescui* and *C. antalyensis* were clustered in the same clade with those *C. baliki* and *C. tinca* merged in the same clade. A low K2P mean genetic divergence of 0.37% was calculated between *C. baliki* and *C. tinca* (Özdemir, 2013; Bektaş et al., 2019) (Table 4).

Discussions

According to Turan et al. (2006), *C. baliki* is distinguished from *C. tinca* by having fewer serrae along posterior margin of last simple dorsal-fin ray (17-23 vs. 24-28), modally fewer scale rows between lateral line and dorsal-fin origin (14 vs. 16), fewer vertebrae (43-44 vs. 44-46), shorter head (21.8-24.5 vs. 23.3-26.7% SL), deeper head (55.6-63.5 vs. 49.3-56.5% HL) and lower caudal peduncle (9.5-12.2 vs. 10.8-13.4% SL). Based on the examined materials, our data in line with pervious findings (Özdemir, 2013, 2015; Kaya, 2019) showed overlapping of all above-mentioned distinguishing characters as well as others (Tables 2 and 3). Therefore, there is no morphological diagnostic characters to distinguish *C. baliki* from *C. tinca*.

Capoeta tinca and *C. baliki* were clustered in the

Table 4. Estimates of average K2P genetic divergence over sequence pairs between the studied *Capoeta* species.

Species	No	1	2	3	4	5	6	7	8
C. baliki	1								
C. tinca	2	**0.37**							
C. damascina	3	3.63	4.19						
C. aydinensis	3	4.29	4.84	3.19					
C. caelestis	4	4.11	4.47	1.43	3.93				
C. antalyensis	5	1.81	2.02	3.77	4.71	4.04			
C. sieboldi	6	4.49	5.07	2.99	4.15	3.58	4.74		
C. bergamae	7	4.74	5.31	3.74	2.61	4.39	5.18	4.83	
C. banarescu	8	4.30	4.33	3.51	5.05	4.18	3.56	5.40	5.53

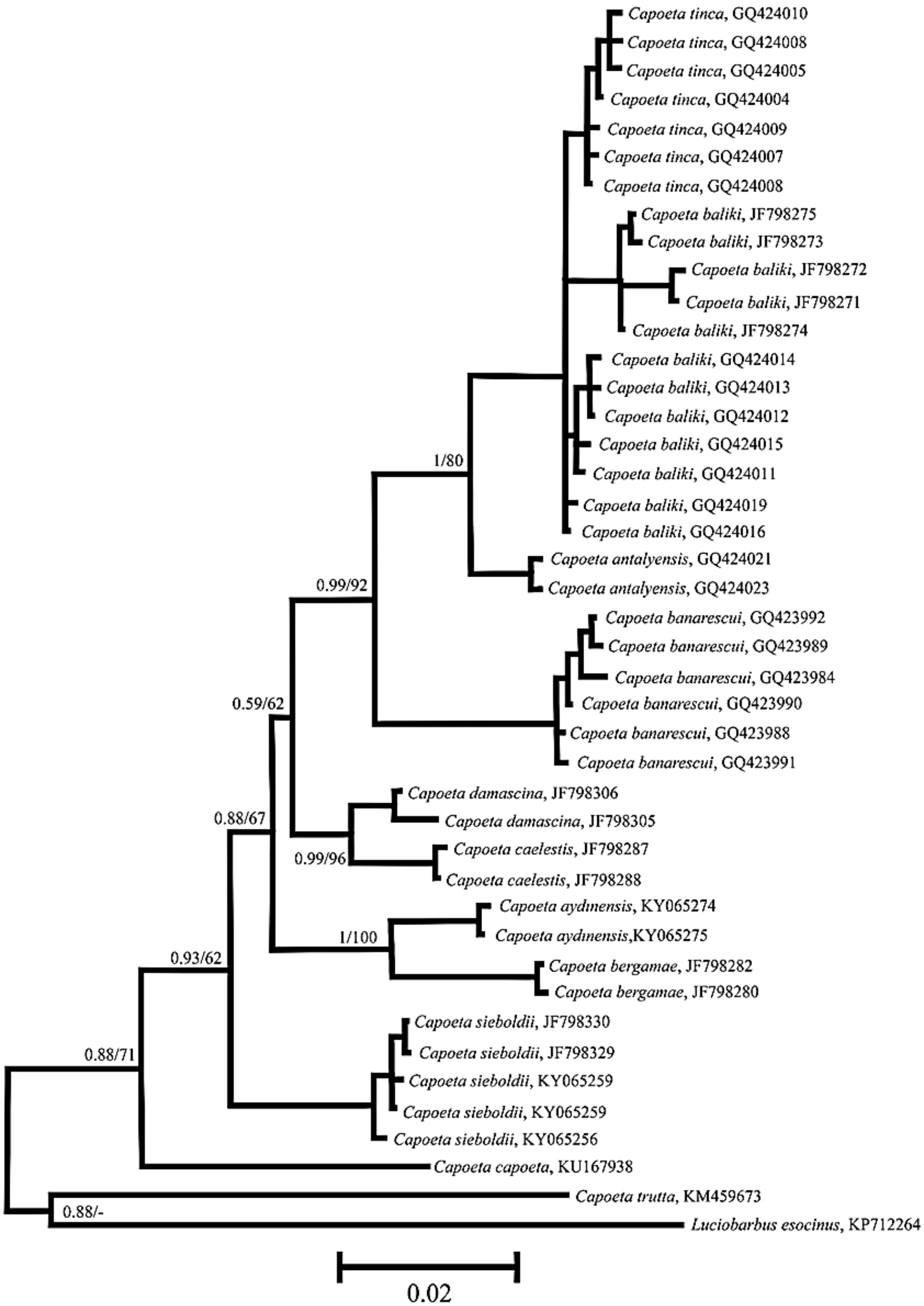

Figure 3. Bayesian Inference of the phylogenetic relationships based on the mitochondrial *cytb* barcode region (values at nodes correspond to BI posterior probability/ ML bootstrap).

same clade and cannot be considered as distinct species based on phylogenetic species concept (PSC). In addition, mean K2P genetic divergence of 0.37% between *C. tinca* and *C. baliki* is low for species delimitation criteria suggested by Geiger et al. (2014) for freshwater fishes of the Mediterranean region and also this genetic distance stands within intraspecific range in the genus *Capoeta* based on the pervious studies (Bektaş et al., 2017, 2019; Ghanavi et al., 2016; Levin, 2012; Zareian and Esmaeili, 2017; Zareian et al., 2018). Furthermore, Bektaş et al. (2017) reported that the haplotypes of *C. baliki* (from Sakarya river drainage and Lake Eber) and *C. tinca* (from Susurluk drainage) are closely related. The basins drain to Black Sea and the Sea of Marmara are not fully isolate from each other and exchanges routes are still available e.g. via river capture (Yıldırım and Emre, 2004). Therefore, *C. tinca* and *C. baliki* have perhaps recently isolated. Moreover, even existence of minor molecular and morphological differences between populations of widespread freshwater fish species, is a well-studied phenomenon (Marcil et al., 2006).

Since no morphological diagnostic characters to distinguish *C. baliki* from *C. tinca* is available and they are identical in molecular characters i.e. *cytb* gene, therefore we treat *C. baliki* as a junior synonym of *C. tinca*.

Material examined. All from Turkey.

Capoeta baliki, NUIC-1816, 20, 90.8-227.3 mm SL; Ankara prov.: Derecik Stream, Sakarya basin, 40°30'44"N 32°19'30"E; 15 May 2018. — ESFM-PISI/2004-74 (Holotype), 202 mm SL; Ankara prov.: Sakarya River: Kizilcahamam Stream, 60 km west of Ankara, 40°29'N 32°39'E; 15 April 2004. — ESFM-PISI/2004-75, 4, 140-190 mm SL; same data as holotype.

Capoeta tinca, NUIC-1717, 20, 90.6-140.7 mm SL; Balıkesir prov.: Değirmen Stream, Susurluk basin, 39°54'50"N 27°33'50"E.

Zoobank Registration: urn:lsid:zoobank.org:pub:729C2166-8359-401D-B3CA-102A9CBACB4B

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References

Altschul S.F., Gish W., Miller W., Myers E.W., Lipman D.J. (1990). Basic local alignment search tool. Journal of Molecular Biology, 215: 403-410.

Armbruster J.W. (2012). Standardized measurements, landmarks, and meristic counts for cypriniform fishes. Zootaxa, 3586: 8-16.

Bektaş Y., Aksu İ., Kaya C., Turan D. (2019). DNA Barcoding of the Genus *Capoeta* (Actinopterygii: Cyprinidae) from Anatolia. Turkish Journal of Fisheries and Aquatic Sciences, 19(9): 739-752.

Bektaş Y., Turan D., Aksu İ., Kaya C., Ciftci Y., Eroglu O., Kalaycı G. Beldüz A.O. (2017). Molecular phylogeny of the genus *Capoeta* (Teleostei: Cyprinidae) in Anatolia, Turkey. Biochemical Systematics and Ecology, 70: 80-94.

Buj I., Podnar M., Mrakovčić M., Ćaleta M., Mustafić P., Zanella D., Marčić Z. (2008). Morphological and genetic diversity of Sabanejewia balcanica in Croatia. Folia Zoologica, 57(1): 100-110.

Çiçek E., Fricke R., Sungur S., Eagderi E. (2018). Endemic freshwater fishes of Turkey. FishTaxa, 3(4): 1-39.

Çiçek E., Sungur S., Fricke R. (2020). Freshwater lampreys and fishes of Turkey; a revised and updated annotated checklist 2020. Zootaxa, 4809(2): 241-270.

Elliott N.G., Haskard K., Koslow J.A. (1995). Morphometric analysis of orange roughy (*Hoplostethus atlanticus*) off the continental slope of southern Australia. Journal of Fish Biology, 46: 202-220.

Geiger M.F., Herder F., Monaghan M.T., Almada V., Barbieri R., Bariche M., Berrebi P., Bohlen J., Casal-Lopez M., Delmastro G.B., Denys G.P., Dettai A., Doadrio I., Kalogianni E., Karst H., Kottelat M., Kovacic M., Laporte M., Lorenzoni M., Marcic Z., Ozulug M., Perdices A., Perea S., Persat H., Porcelotti S., Puzzi C., Robalo J., Sanda R., Schneider M., Slechtova V., Stoumboudi M., Walter S., Freyhof J. (2014). Spatial heterogeneity in the Mediterranean biodiversity hotspot affects barcoding accuracy of its freshwater fishes. Molecular Ecology Resources, 14(6): 1210-1221.

Geldiay R., Balik S. (2007). Freshwater Fishes of Turkey. V. Edition, Ege University Press, Bornova, Izmir. 638 p.

Ghanavi H.R., Gonzalez E.G., Doadrio I. (2016). Phylogenetic relationships of freshwater fishes of the genus *Capoeta* (Actinopterygii, Cyprinidae) in Iran. Ecology and Evolution, 6: 8205-8222.

Kalyaanamoorthy S., Minh B.Q., Wong T.K.F., von Haeseler V., Jermiin L.S. (2017). ModelFinder: fast model selection for accurate phylogenetic estimates.

Nature Methods, 14: 587-589.

Kaya C. (2019). Taxonomic revision of the species belonge to the genus *Capoeta* by using both the distributed in Turkey. Ph.D. thesis, Recep Tayyip Erdogan University, Rize. 126 p.

Küçük F., Turan D., Turna I.I. (2008). Comparing the osteological characteristics of some *Capoeta* (Teleostei: Cyprinidae) species distribution in Anatolia. E.U. Journal of Fisheries and Aquatic Sciences, 25(4): 267-273.

Levin B.A., Freyhof J., Lajbner Z., Perea S., Abdoli A., Gaffaroğlu M., Özulug M., Rubenyan H.R., Salnikov V.B., Doadrio I. (2012). Phylogenetic relationships of the algae scraping cyprinid genus *Capoeta* (Teleostei: Cyprinidae). Molecular Phylogenetics and Evolution, 62: 542-549.

Marcil J., Swain D.P., Hutchings J.A. (2006). Genetic and environmental components of phenotypic variation in body shape among populations of Atlantic cod (*Gadus morhua* L.). Biological Journal of the Linnean Society, 88(3): 351-365.

Nguyen N.D., Mirarab S., Kumar K. (2015). Ultra-large alignments using phylogeny-aware profiles. Genome Biology 16: 124.

Özdemir F. 2013. The revision of species and subspecies of the genus *Capoeta* (Teleostei: Cyprinidae) by using both the classical systematic and molecular systematic methods in Turkey. Ph.D. thesis, Hacettepe University, Ankara. 171 p.

Özdemir F. (2015). principle components analysis of two pairs of Barbels Species of the Genus *Capoeta* (Teleostei: Cyprinidae) in Turkey. Pakistan Journal of Zoology, 47(3): 753-762.

Rambaut A., Drummond A.J. (2013). Tree Annotator v1.8.0 MCMC Output Analysis.

Ronquist F., Teslenko M., van der Mark P., Ayres D.L., Darling A., Höhna S., Larget B., Liu L., Suchard M.A., Huelsenbeck J.P. (2012). MrBayes 3.2: Efficient bayesian phylogenetic ınference and model choice across a large model space. Bioanformatics, 61: 539-542.

Tamura K., Stecher G., Peterson D., Filipski A., Kumar S. (2013). MEGA6: Molecular Evolutionary Genetics Analysis Version 6.0. Molecular Biology and Evolution, 2013 Dec; 30(12): 2725-2729.

Turan D., Kottelat M., Ekmekçi F.G., Imamoğlu H.O. (2006). A review of *Capoeta tinca*, with descriptions of two new species from Turkey (Teleostei: Cyprinidae). Revue Suisse de Zoologie, 113(2): 421-436.

Yıldırım C., Emre O. (2004). Drainage evolution along the north Anatolian fault zone, eastern Marmara-Turkey. In: Denver Annual Meeting, 19-24.

Zareian H., Esmaeili H.R. (2017). Mitochondrial phylogeny and taxonomic status of the *Capoeta damascina* species group (Actinopterygii: Cyprinidae) in Iran with description of a new species. Iranian Journal of Ichthyology, 4(3): 231-269.

Zareian H., Esmaeili H.R., Gholamhosseini A., Japoshvili B., Ozulug M., Mayden R.L. (2018). Diversity, mitochondrial phylogeny, and ichthyogeography of the *Capoeta capoeta* complex (Teleostei: Cyprinidae). Hydrobiologia, 806: 363-409.