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Principle Components Analysis of Two Pairs of Barbels Species of the Genus *Capoeta* (Teleostei: Cyprinidae) in Turkey*

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Abstract.- There is a wide variation both in the population and inter – populations of the species of the genus *Capoeta* in Turkey. The Principal Components Analysis (PCA) was performed using metric and meristic characters to analyze these variations. According to results of PCA it was determined that *Capoeta banarescui* living in the basin of Çoruh and *Capoeta baliki* dwelling in the basins of the Sakarya and Kızılırmak Rivers are of the same species as *Capoeta tinca,* whereas the *Capoeta antalyensis* living in the basin of the Mediterranean Sea is a different species.

Key words: *Capoeta tinca, Capoeta antalyensis, Capoeta baliki, Capoeta banarescui,* taxonomic revision, principal components analysis (PCA).

INTRODUCTION

The genus *Capoeta* belonging to Cyprindae family is one of the largest groups exhibiting the widest distribution in Turkey. Seven species (*C. barroisi, C. buhsei, C. capoeta, C. fusca, C. pestai, C. tinca* and *C. trutta*) belonging to the genus *Capoeta* distributed in Turkey and the Near East were revised by Karaman in 1969. From amongst these species, it was found that *C. fusca* and *C. buhsei* were absent in Anatolia. Karaman (1969) also listed 11 subspecies of *Capoeta capoeta*. During the last decade, five new species namely *C. ekmekciae* (Turan *et al*., 2006a), *C. turani* (Ozulug and Freyhof, 2008), *C. erhani* (Turan *et al*., 2008), *C. caelestis* (Schöter *et al*., 2009) and *C. mauricii* (Kucuk *et al*., 2009) have been described from Çoruh, Seyhan and Ceyhan, Göksu River Basins and Beyşehir Lake, respectively. However according to a study carried out by Erkakan and Özdemir (2011) it was argued that *C. turani* and *C. erhani* were synonymous to *C. barroisi.*

Capoeta tinca, two pairs of barbels species, inhabits the Central and Northern Anatolian River Basins. This species was described by Heckel as *Scaphiodon tinca* in the Nilufer Stream in 1843 (the Marmara Basin). Later on, it was reported as *Varicorhinus tinca by* Steindachner (1897), Derjugin (1899) and Leidenfrost (1912) and Berg (1949). But the members of genus *Varicorhinus* were included in the genus *Capoeta* by Karaman (1969). Later on, this species was accepted as *Capoeta tinca* by many authors (Kuru, 1975; Balık, 1979; Erkakan, 1981; Kutrup, 1994). Banarescu (1999) reported that distribution area of this species extends from the Nilüfer Stream (Marmara Basin) to Rion River (Eastern Black Sea Basin, Georgia). In the same study, Banarescu also mentioned that there are considerable differences between the population in the Çoruh Basin and those in Bursa, which inhabit the Sakarya, and Kızılırmak Basin in western and central Anatolia. The number of scales in the lateral line, which range from 67 to 80 in the Çoruh River population and from 72 to 87 in western and central Anatolia and specimens from northwestern and western Anatolia have shorter barbels. At the same time, Banarescu (1999) suggested that *C. tinca* may have been a distinct subspecies in rivers of northeastern Anatolia.

During a revision of *C. tinca* species complex, Turan *et al.* (2006b) reported that *C. tinca* lives only in the rivers flowing into the Marmara Sea. They described *C. baliki* in the rivers flowing into the Southwestern Black Sea and *C. banarescui* in the Çoruh River.

According to the study carried out using the 16SrRNA gene, Bektaş *et al.* (2011) mentioned that *C. tinca* living in Anatolia is genetically different from *C. banarescui*. The 16SrRNA gene analysis is however insufficient to distinguish closely related

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species.

The aim of this study is to, by using classic systematic methods, reveal whether or not *C. baliki* and *C. banarescui*, which were described with minor morphologic distinctions and wrong description (*e.g.*, mouth shape sexually dimorphic) by Turan *et al.* (2006b), are different from *C. tinca* and *C. antalyensis* belonging to the genus *Capoeta* with two pairs of barbel living in different basins of Anatolia.

Table I.- Sampling locations of two pairs barbel species belonging to the genus *Capoeta*.

Locations (Basin)	Sampling Location	n
Çoruh	Çoruh River Aşağıcala-Yusufeli	15
Yeşilırmak	Kalecik Village, Suluova, Cemilbey	30
Kızılırmak	Kırşehir-Sdıklı,Bala-Balaban, Yerköy-Delice,Sivas-İmralı	28
Sakarya	Güdül Village,Güvem Village Kızılcahamam Village	37
Western Blacksea	Dörtdivan-Bartın, Yenikışla-Bartın	36
Susurluk	Karaçaltı-Kepsut	18
Konya Closed	Peçenek	10
Lakes Region	Kütahya-Araplı	6
Akdeniz	Antalya-Aksu	17

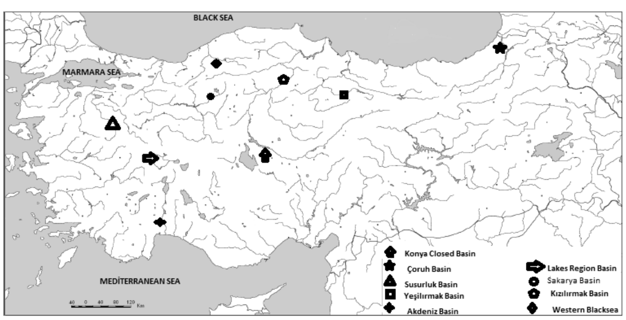

Fig. 1. Distribution of two pairs barbel species belonging to genus *Capoeta* in Turkey.

MATERIALS AND METHODS

Fish samples were caught with electro-fishing equipment from 9 basins (Table I, Fig. 1). Lagler *et al.* (1977) was followed for taking measurements for taxonomic studies using millimeter ruler and a digital caliper with 0.01 mm sensitivity. Other than this, various morphologic characteristics like number of rakers in the 1st gill arch were also recorded. The data was analyzed statistically using PAST computer program. Logarithm of the data was taken and Primary Components Analysis (PCA) methods were applied (Hammer *et al.*, 2005). A correlation matrix was also developed and the primary components whose eigenvector values were above the unit were considered for developing the correlation.

RESULTS AND DISCUSSION

Turan *et al.* (2006b) reported that *C. tinca* lives in the rivers flowing into the Marmara Sea, whereas *C. baliki* lives in the rivers flowing into the southwestern part of the Black Sea and *C. banarescui* lives in the Çoruh River. We examined 26 samples of *C. banarescui* from Tortum and Bulanık creeks (Çoruh Basin). They differed from *C. tinca* and *C. baliki* in terms of number of lateral lines which is in the range of 64–77 and number of gill rakers which is in the range of 12–16, the snout being more pointed and lack of sexual dimorphism in their mouth shapes.

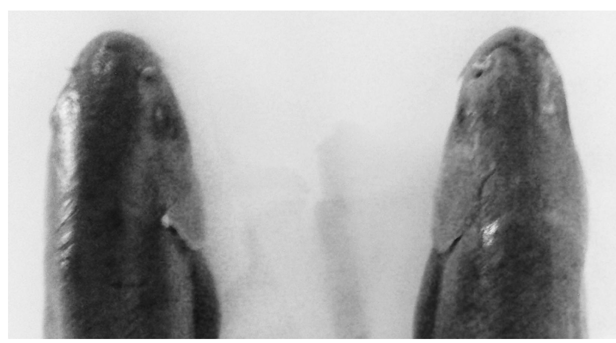

Fig. 2. Snout shape of C. *tinca* (left side) and *C. banarescui* (right side).

According to Kuru (1975), the number of lateral lines for 324 *C. tinca* samples caught in the rivers flowing into the Black Sea is between 67 and 80 and the number of gill rakers is between 19 and 23. The number of lateral lines in the 15 samples examined during a study we carried out with the individuals belonging to the genus *Capoeta* with two pairs of barbel caught from the Aşağıcala creek (the Yusufeli–Çoruh Basin) is in the range of 69–80

Table II.- I gill rakers number of two pairs barbel species belonging to genus *Capoeta*.

Locations (Basin)	10	12	13	14	15	16	17	18	19	20	21	N
Çoruh	–	–	–	1	4	5	5	–	–	–	–	15
Yeşilırmak	–	–	–	–	6	14	7	3	–	–	–	30
Kızılırmak	2	1	–	3	4	7	7	3	1	–	–	28
Sakarya Basin	–	–	–	–	1	2	6	12	10	6	–	37
Western Blacksea	–	–	1	11	14	5	3	1	1		–	36
Susurluk Basin	–	–	–	–	–	–	1	6	6	3	2	18
Konya Closed	–	–	–	–	5	2	2	1	–	–	–	10
Lakes Region	–	–	–	–	–	–	2	1	1	1	1	6

and the number of gill rakers is in the range of 14–17 (Tables II, III, IV). Within the population, both sharp and round–snouted individuals were observed (Fig. 2). Some morphometric values of the samples are as follows: head length 21.25% of the standard length (vs. 22.2–25%); The head width taken from the posterior of the eye is 50.9–57.2% of the head length (vs. 49.4–58.2%); The snout height is 23.4-27.4 % of the head length (vs.18.4–28.8%); anterior barbel length 15.1–18.3% of the head length (vs. 12.4–20.8%) and the posterior barbel length 18.9-25.2 % of the head length (vs. 18.4–28.8%) (Turan *et al.*, 2006b) (Tables V, VI). In addition, as for the *C. baliki* described by Turan *et al.* (2006b) in the same study upon having examined 25 samples from the Kızılcahamam creek, the Ova stream (the Sakarya Basin) and the Kızılırmak River and the Delice creek, it has been specified that the *C. baliki* distinguished from the other species of the genus by its two pairs of barbels, number of lateral lines being 72–86, number of gill rakers being 16–22 and the mouth shape of the females being straight and males being arched.

However, according to the study carried out by Erkakan in 1981, it was determined that the number of lateral line scales for the 449 individuals of *C. tinca* caught from the Sakarya Basin was 63–88 and the number of gill rakers was 10–19. In addition, its mouth structure is on ventral side, circular and longitudinal. We studied 65 individuals of genus *Capoeta* with two pairs of barbels caught from the Güdul creek, the Kızılcahamam creek, the Güvem creek (Sakarya Basin) and the Delice creek, the Sıdıklı creek, the Balaban creek, the Imrali creek (the Kızılırmak Basin) and observed that there was no mouth shape dependent sexual dimorphism and the variances in mouth shape are independent of sex.

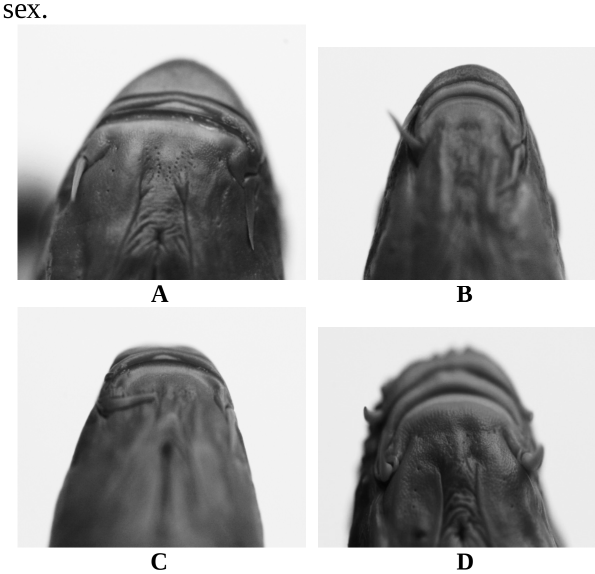

Fig. 3. Mouth shape of *Capoeta baliki;* A. less convex (female); B, very convex (female), C, less convex (male); D, very convex (male)

The arched and straight mouth structure is present in both sexes (Fig. 3), while the number of lateral line scales is in the range of 67–83, the number of gill rakers is in the range of 10–20 (Tables II, IV). Some morphometric values are as follows; head length 22.2–27.2% of the standard length (vs. 21.9–24.8%,); the head width taken from the posterior of the eye 50.2–60.7% of the head length (vs.55.6 – 63.5%); the snout height 25–28.5% of the head length (vs. 33.1–41.6%), the anterior barbel length 70.2–17.5% of the head length (vs. 98–18.7%) and the posterior barbel length 11.3–22% of the head length (vs. 14.7–25.5%,) (Turan *et al.*, 2006b) (Tables V, VI).

Table III.- Lateral line scales of two pairs barbel species belonging to genus *Capoeta* except of *C. Antalyensis*.

Locations (Basin)	62	63	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	87	N
Çoruh	–	–	–	–	–	1	1	1	1	1	3	–	2	3	1	–	1	–	–	–		–	–	15
Yeşilırmak	–	–	1	1	1	1	1	5	2	2	3	4	1	3	3	1	1	–	–	–		–	–	30
Kızılırmak	–	–	–	1	–	1	2	2	3	4	–	3	2	1	2	2	2	2	–	1			–	28
Sakarya	–	–	–	1	–	1	1	2	2	4	6	1	2	5	6	2	2	–	1	1			–	37
Western Blacksea	1	2	–	1	6	3	2	1	5	2	4	5	2	2	–	–	–	–	–	–		–	–	36
Susurluk	–	–	–	–	–	–	–	–	–	1	2	2	5	1	–	1	1	1	1	1	1	1		18
Konya Closed	–	–	–	–	–	1	–	–	2	1	1	1	1	1	–	–	1	1	–	–		–	–	10
Lakes Region	–	–	–	–	–	1	–	–	–	–	–	–	1	–	–	–	1	–	–	2		–	1	6

Considering the basins, it is clearly seen that there is a wide variation within the population and at the same time, there is an overlap between populations. The number of lateral line scales and the number of gill rakers of *C. banarescui* (Çoruh River) and *C. baliki* (Sakarya and Kızılırmak River Basin) described by Turan *et al.* (2006b) are consistent with the data we obtained from this study (Tables II, III). According to Turan *et al.* (2006b) branched dorsal-fin ray from meristic characters for *C. baliki* living in the Sakarya Basin has been found to be 8-9 and *C. banarescui* living in the Çoruh River Basin determined 7-9 and *C. tinca* living in the rivers flowing into the Marmara Sea determined 8 and as for the branched pelvic fin ray; 9-10 for *C. baliki* and *C. banarescui* and 8–9 for *C. tinca.* As for the anal fin ray, it was determined 5 in all three species. These values are consistent with our data (Table VII). When both metric and meristic characteristics were evaluated, there was not a great difference between the basins.

Bektaş *et al*. (2011) mentioned that two pairs of barbels species of the genus *Capoeta* caught from Çoruh Basin are genetically different from *C. tinca* caught from the Marmara Basin. Samples caught from this location were described as *C. banarescui* by Turan *et al.* (2006b) although it was accepted as *C. tinca*, the reason for which was not expressed. They reported that the samples caught in the Yeşilırmak Basin (Harsit and Aluca locations) were different from *C. banarescui*. They did not include populations of *C. baliki* which live in the Sakarya and Kızılırmak Basin. Since sampling from populations geographically distant from one another would widen the range of variation and would not give accurate picture. In addition intermediate populations should also be evaluated. In addition, it was suggested that since gene flow did not occur among these three populations due to geographical barriers, genetic differences therefore have developed. The Black Sea has turned into a freshwater lake along the interglacial epoch (Banarescu, 1990) and it turned into a brackish water flow due to the Mediterranean Sea's water flowing into the Black Sea 6,000 – 7,500 years ago (in the early Holocene epoch) (Ryan *et al.*, 1997). One of the factors which lead to the dispersion of freshwater animals from one river basin to another

Table IV.- Lateral line scales of *Capoeta antalyensis.*

Locations (Basin)	50	51	52	53	54	55	56	57	58	N
Aksu River(Akdeniz Basin)	1	2	1	2	1	4	4	1	1	17

is the transformation of a sea partially or completely into freshwater, just like the Baltic, Caspian and Black Sea which were once slightly brackish. The species belonging to the genus *Capoeta* are likely to adapt themselves easily to the high-salinity waters.

Erkmen and Kolankaya (2000) studied chloride cells of *C. tinca* in the Kızılırmak River and determined that they can easily survive in the waters possessing a 10.5 ‰ salinity ratio due to chloride cells developed by the members of *C. tinca.* The salinity of the Black Sea varies between 18 and 20‰ and this value dropped to 14‰ due to precipitations and discharge of rivers in the northeastern regions (Anonymous, 1997). During the period when precipitations and discharges were dense, the species belonging to the genus *Capoeta* living in this region could switch to different water systems via the Black Sea shores. Furthermore, the time required for the formation of physical barriers might not be sufficient for the process of speciation. The effectiveness of geographic barriers depends on their age. Formation of the geographic barriers may lead to a wide variation among the populations in the groups possessing a large ecologic tolerance like the genus *Capoeta* in a lingering evolution process. On the other side, even if the barriers had developed, transfer of species from one basin to another due to the formation of an aquatic fauna river capture can take place (Banarescu, 1990). In addition, 16SrRNA is not as effective as Cytb and the COI gene for identification of closely related species (Kochzius and Seidel, 2010). In the present study sequence difference values in the gene marker were between 0.96–1.35 and displayed considerably low species distinction. Therefore, this study carried out by using only the 16SrRNA gene is insufficient to distinguish closely related species and it should be supported by addition of COI or cytb.

The PCA is a statistical procedure that transforms a number of possibly correlated variables into a smaller number of uncorrelated variables called principal components (Nawaz *et al*., 2011). It was performed to evaluate the differences among the samples caught from different basins in terms of morphometric characters. To do so, a correlation matrix was developed. In the correlation, the primary components possessing eigenvector values above unit values were taken into account. It can be seen that none of the groups diverged from each other in terms of the first two eigenvectors (Fig. 4a) however, when looking at vectors 1 and 3 (Fig. 4b), three groups differed from the others. Among these three regions, the highest differentiation is in the population of the Mediterranean Sea Basin (of *Capoeta antalyensis*), followed by the population of the Lakes Region Basin and the population of the Susurluk Basin. When the 2nd and 3rd vectors were examined (Fig. 4c), it was observed that only the population of the Mediterranean Sea Basin differs (*C. antalyensis*). When, the same data were evaluated with a nonmetric multidimensional scaling, Euclidean similarity distance, it was observed that only the population of the Mediterranean Sea Basin (*C. antalyensis*) exhibited distinction on the plane of the 1st and 2nd coordinates and the variance of the Western Black Sea population was higher. Again, a multi–way variance analysis carried out using the same data produced the same results (Fig. 4d). According to these results, only the species living in the Mediterranean Sea Basin are different from the species belonging to the two pairs of barbels genus *Capoeta* between the basins. The species belonging to the genus *Capoeta* with two pairs of barbels living in this basin is *Varicorhinus antalyensis*, described by Battalgil in 1944, is a valid species. Later on, this species was included in genus *Capoeta* (Erkakan and Kuru, 1983).

Turan *et al.* (2006b) identified the species they caught in the Nilufer Stream and Koca Stream (the rivers flowing into the Marmara Sea) the two pairs of barbels of the population of the genus *Capoeta* as *C. tinca*. These regions are located within Susurluk Basin and they are found in the

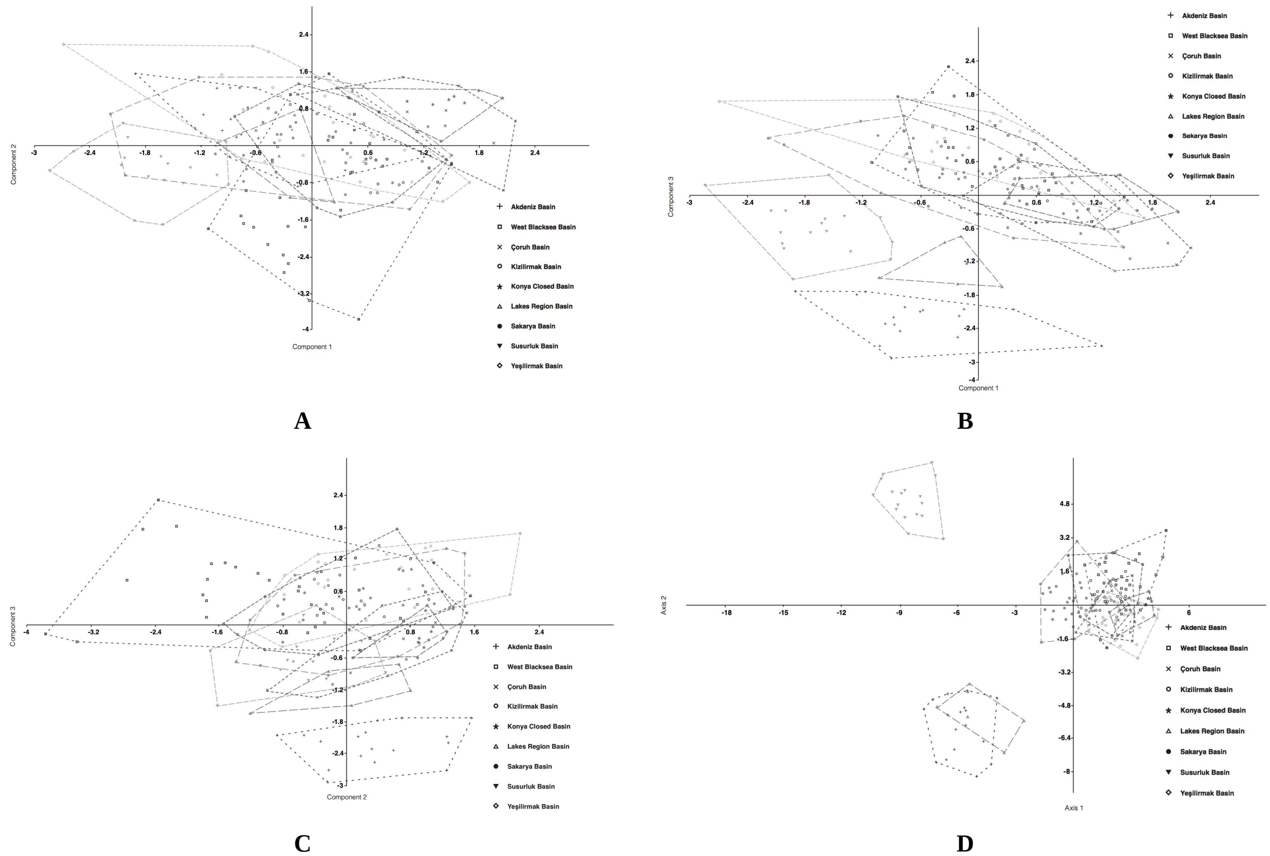

Fig. 4. The Principle Component Analysis (PCA) of two pairs barbel species belonging to genus *Capoeta*. (A,B,C). The first primary components explain 42,64% (A), 16,02% (B) and 9,46% (C) of total variance, (D) shows Canonical Variance Analysis (CVA) (Wilks'lambda: 0,003, F:16,56, p<0,0001)

same basin where we have caught from Karaçaltı Stream. According to classic systematic analysis and unpublished DNA barcoding analysis the species caught in the region that belongs to the two pairs barbels of the genus *Capoeta* are no different from the genus *Capoeta* with two pairs of barbels living in other basins, other than *C. antalyensis*. Similarly, the genetic and morphometric studies suggest that *Capoeta banarescui* living in the Çoruh Basin is the same species as *C. baliki* living in the Sakarya and Kızılırmak River Basins.

CONCLUSIONS

In conclusion, as seen from the studies carried out, there is a wide in–population and also inter–population variation within the species belonging to the genus *Capoeta*. Once number of samples was increased, this variation becomes even wider. For this reason, the differences seen in some characters among the populations found in different geographic areas can only be determined based on whether or not the difference is meaningful upon examination and evaluation of the intermediate populations. Taking the intermediate populations into evaluation is a key point and decreases the probability of error in the groups whose ecological tolerance is higher and variation range is wider, like the *Capoeta* genus in systematic studies. Assessment of populations found at geographically different points from each other may lead to suspicion on whether these two populations are of different species or suggest that they belong to the same racial rings but were exposed to utmost differentiation.

Table V.- **Morphometry of two pairs barbel species belonging to genus *Capoeta* in Çoruh, Kızılırmak, Sakarya and West Blacksea Basin.**

In percent of standard length	Çoruh Basin (n:15)				Kızılırmak Basin (n:28)				Sakarya Basin (n:37)				West Blacksea Basin (36)			
	Mak	Min	Ort	Sd	Mak	Min	Ort	Sd	Mak	Min	Ort	Sd	Mak	Min	Ort	Sd
Head lenght	25.0	21.1	23.5	1.0	25.7	21.0	24.0	0.9	27.2	22.2	24.7	1.0	25.9	22.8	24.4	0.9
Maximum body depth	24.5	21.7	23.1	0.9	25.7	18.0	22.9	1.9	25.7	21.7	23.8	1.0	25.5	20.9	23.1	1.2
Dorsal fin lenght	20.4	16.2	18.0	1.0	21.2	16.6	19.1	1.0	23.4	16.2	19.8	1.5	24.4	17.4	19.1	1.3
Dorsal fin height	27.1	23.1	25.4	1.3	28.2	22.8	25.3	1.3	32.8	22.4	27.5	2.2	28.2	20.9	25.0	1.7
Anal fin lenght	12.6	7.7	9.8	1.1	11.9	8.8	10.0	0.9	10.9	7.8	9.4	0.7	20.8	9.0	10.5	1.9
Anal fin height	24.9	19.2	21.3	1.5	21.8	16.0	18.5	1.5	21.4	15.4	18.9	1.3	22.2	15.8	19.3	1.6
Ventral fin lenght	18.4	15.8	17.0	0.8	17.3	13.8	15.4	1.0	17.9	13.7	16.1	0.9	17.1	13.5	15.6	0.9
Pectoral fin lenght	20.7	18.5	19.7	0.7	20.1	16.4	18.1	0.8	21.1	16.9	18.6	0.9	19.9	15.1	17.7	1.4
Predorsal lenght	47.1	43.6	45.1	1.0	47.3	42.7	44.4	1.2	48.0	42.9	45.5	1.1	47.3	44.1	45.7	0.8
Postdorsal lenght	42.8	36.8	40.6	1.5	42.0	36.7	39.3	1.3	42.0	36.9	39.1	1.1	42.4	37.4	39.9	1.1
Preventral lenght	54.6	51.2	52.4	1.0	55.5	51.0	53.2	1.1	56.6	51.0	53.1	1.3	54.8	50.7	52.9	1.0
Postventral lenght	46.8	43.8	45.2	0.8	48.7	43.1	45.0	1.2	47.6	41.9	45.0	1.3	47.9	42.7	45.2	1.1
Preanal lenght	72.3	67.5	70.6	1.4	74.7	69.7	71.8	1.3	74.3	70.1	72.2	1.0	74.3	69.6	72.0	1.0
Pectoral fin origin to anal fin	51.4	47.3	50.0	1.2	54.3	48.2	50.4	1.6	52.1	46.8	50.1	1.5	52.1	47.3	50.0	1.3
Pectoral fin origin to ventral fin	32.5	29.3	31.1	1.0	36.3	28.7	31.1	1.4	33.4	28.7	30.3	0.9	32.4	28.7	30.5	0.9
Ventral fin origin to Anal fin	20.7	16.8	19.1	1.3	22.0	17.8	19.6	1.2	22.3	18.2	20.0	1.0	21.6	17.3	19.5	1.1
Lenght of caudal peduncule	22.9	19.9	21.2	0.8	22.3	17.8	20.2	1.1	22.4	18.8	20.5	0.8	22.2	19.2	20.5	0.8
Lenght of upper caudal-fin lob	22.8	18.6	20.7	1.3	23.6	18.6	20.8	1.4	23.4	19.5	21.6	1.0	22.8	15.9	19.2	1.9
Lenght of lower caudal-fin lob	22.4	18.7	21.0	1.3	23.7	19.4	21.0	1.2	23.4	19.6	21.6	1.0	22.5	16.0	19.3	1.9
Lenght of middle caudal-fin lob	10.5	8.0	9.4	0.7	12.4	9.3	10.3	0.7	11.8	9.2	10.6	0.6	11.5	8.2	9.9	0.6
In percents of head lenght																
Head depth at interorbital	55.8	50.8	52.4	1.3	57.2	51.3	54.0	1.9	59.0	52.0	55.8	1.9	1.3	55.9	51.4	53.7
Baş depth at occipital	69.7	63.3	65.8	1.9	71.2	62.6	67.4	2.6	76.3	65.8	69.8	2.3	1.8	69.6	63.3	67.1
Baş width at anterior eye	43.8	40.2	42.0	1.3	50.1	38.4	42.4	2.3	49.2	37.3	42.7	2.4	1.7	44.4	39.3	41.7
Baş width at posterior eye	57.2	50.9	54.2	2.0	56.6	52.4	54.9	1.2	60.7	50.2	56.0	2.3	1.7	57.3	52.3	55.0
Baş width at at operculum	62.6	56.0	58.9	1.9	62.8	55.1	60.0	2.0	67.6	55.2	61.6	2.8	1.2	61.5	57.4	59.5
Eye diameter	22.2	16.6	19.4	1.7	21.8	17.4	19.6	1.4	31.3	18.4	21.7	2.1	1.1	22.8	19.0	21.0
Interorbital width	40.6	34.4	38.3	1.8	38.8	33.6	36.5	1.5	41.9	31.0	37.1	2.2	1.4	40.3	36.0	37.7
Preorbital lenght	36.8	30.9	33.8	1.8	37.2	28.5	33.1	2.4	37.4	29.2	33.1	1.7	1.4	34.9	30.0	32.4
Snout width at nostrils	27.5	21.9	24.6	1.7	26.9	21.2	24.4	1.4	29.2	21.8	25.0	1.8	1.1	26.8	21.8	24.2
Snout lenght at nostril	27.4	23.4	25.6	1.3	27.8	23.3	25.2	1.5	28.5	22.3	25.0	1.5	1.5	27.2	19.5	24.2
Postorbital lenght	52.6	48.0	50.1	1.2	50.2	46.2	48.3	1.3	50.7	44.8	47.1	1.3	1.1	50.5	46.1	47.9
Mouth width	35.2	30.6	32.7	1.9	31.6	27.2	29.3	1.4	35.2	27.8	32.0	1.7	2.2	34.3	25.0	29.7
Barbel lenght 1(upper)	18.3	15.1	16.9	1.0	17.5	11.6	14.5	1.5	13.1	7.0	9.7	1.3	4.1	19.1	5.7	12.7
Barbel lenght 2(lower)	25.2	18.9	21.4	1.7	22.0	14.5	17.9	2.0	17.8	11.3	14.9	1.4	4.8	21.3	7.5	14.9

Table VI.- **Morphometry of two pairs barbel species belonging to genus *Capoeta* in Susurluk, Yeşilırmak, Lakes Region ve Konya Closed Basin.**

	Susurluk Basin (n:18)				Yeşilırmak Basin (n:30)				Lakes Region Basin (n:6)				Konya Closed Basin (n:10)			
In percent of standard length	**Mak**	**Min**	**Ort**	**Sd**	**Mak**	**Min**	**Ort**	**Sd**	**Mak**	**Min**	**Ort**	**Sd**	**Mak**	**Min**	**Ort**	**Sd**
Head lenght	25.4	23.6	24.6	0.5	28.1	22.9	25.1	1.1	27.4	23.0	25.0	1.6	25.6	22.6	23.6	0.9
Maximum body depth	25.9	22.6	24.6	1.0	27.5	22.7	24.7	1.4	27.8	23.6	24.7	1.6	26.1	23.1	24.5	1.2
Dorsal fin lenght	18.1	14.9	16.8	0.8	25.0	17.6	21.2	1.7	18.8	16.5	18.0	0.8	23.6	18.2	19.7	1.5
Dorsal fin height	25.4	20.8	23.4	1.2	32.2	24.0	28.0	1.8	29.5	25.2	27.1	1.9	27.1	22.5	25.6	1.3
Anal fin lenght	10.3	7.6	8.6	0.6	12.9	8.7	10.4	1.0	9.0	7.4	8.3	0.5	10.6	8.8	9.8	0.6
Anal fin height	19.1	15.8	17.6	0.8	22.7	13.2	19.6	1.7	20.2	37.3	19.1	0.8	23.0	18.2	20.2	1.9
Ventral fin lenght	17.0	13.7	15.7	0.8	17.1	14.4	15.8	0.7	17.9	15.1	16.3	1.0	17.3	15.3	16.4	0.6
Pectoral fin lenght	18.5	16.4	17.3	0.7	20.6	17.3	18.6	0.9	18.6	16.8	17.6	0.8	20.8	19.1	19.9	0.6
Predorsal lenght	51.1	46.1	48.0	1.2	47.0	41.1	43.6	1.6	46.9	44.3	45.6	1.1	47.1	43.8	45.5	1.1
Postdorsal lenght	39.4	35.6	37.8	1.0	41.7	32.9	38.9	1.7	39.9	37.0	38.1	1.3	42.6	38.6	40.8	1.4
Preventral lenght	55.0	51.8	53.3	1.1	58.7	51.1	53.7	1.4	54.5	50.7	53.1	1.4	54.3	50.9	52.4	1.0
Postventral lenght	46.3	43.0	44.6	1.1	47.1	40.8	44.8	1.3	45.2	42.0	43.5	1.1	47.0	44.6	45.7	0.8
Preanal lenght	75.4	70.8	72.4	1.2	77.0	69.2	71.9	1.4	73.4	70.1	71.1	1.2	72.8	69.7	71.0	0.9
Pectoral fin origin to anal fin	52.1	46.2	49.9	1.5	52.4	47.4	49.7	1.5	52.1	47.1	49.2	1.9	52.3	47.9	50.0	1.4
Pectoral fin origin to ventral fin	32.6	28.7	31.3	1.0	32.9	29.1	30.9	0.8	31.2	29.0	30.1	0.8	32.9	28.8	30.7	1.1
Ventral fin origin to Anal fin	17.4	14.1	15.7	0.9	21.6	18.0	19.0	1.3	22.2	18.0	19.6	1.6	21.2	17.8	19.7	1.0
Lenght of caudal peduncule	21.4	18.5	19.5	0.8	21.0	16.6	19.5	1.1	19.6	18.3	19.0	0.5	23.3	19.9	21.0	1.2
Lenght of upper caudal-fin lob	25.0	18.5	22.4	1.7	23.7	18.4	20.8	1.4	20.5	17.5	18.9	1.0	23.5	21.3	22.2	0.7
Lenght of lower caudal-fin lob	24.5	19.1	22.5	1.3	23.5	18.4	21.0	1.4	21.5	18.9	20.2	1.1	23.3	21.6	22.3	0.6
Lenght of middle caudal-fin lob	11.4	9.5	10.4	0.6	12.1	8.2	10.5	1.0	11.8	9.4	10.7	0.8	12.0	10.2	11.2	0.6
In percents of head lenght																
Head depth at interorbital	62.6	55.8	58.7	1.7	56.8	50.3	53.2	1.5	56.4	53.4	55.2	1.3	54.8	49.9	52.4	1.7
Baş depth at occipital	75.6	68.8	72.1	1.9	73.4	67.2	70.2	1.7	78.5	76.2	77.4	0.9	72.0	68.1	70.0	1.2
Baş width at anterior eye	45.4	38.9	42.3	1.7	45.9	40.5	43.6	1.5	42.9	39.8	41.7	1.1	48.0	43.5	45.6	1.3
Baş width at posterior eye	55.1	48.4	51.9	1.9	60.3	53.8	56.8	1.7	55.9	52.6	54.2	1.1	61.8	56.9	58.8	1.5
Baş width at at operculum	65.9	60.2	62.8	1.9	64.8	59.1	61.9	1.6	66.3	62.3	63.8	1.8	66.1	62.6	64.2	1.1
Eye diameter	22.5	18.7	20.7	1.0	23.2	16.9	20.1	1.7	18.2	16.8	17.7	0.7	21.7	16.3	18.9	1.4
Interorbital width	37.6	32.7	35.9	1.3	40.2	35.0	37.1	1.5	41.7	38.4	40.2	1.2	41.1	36.9	39.3	1.5
Preorbital lenght	32.7	29.5	31.2	0.9	36.7	30.0	33.0	1.7	38.7	34.6	36.4	1.3	37.8	33.2	34.8	1.3
Snout width at nostrils	27.3	21.2	24.1	1.8	27.5	21.9	24.9	1.4	24.1	20.3	22.2	1.6	28.6	24.4	26.3	1.6
Snout lenght at nostril	24.8	18.9	22.7	1.7	27.4	22.2	25.3	1.3	29.6	25.1	27.4	2.0	29.6	23.3	27.0	1.8
Postorbital lenght	51.0	47.0	49.0	1.1	53.2	45.3	47.8	1.6	52.9	49.7	51.2	1.2	49.4	45.8	47.3	1.1
Mouth width	32.1	28.6	30.5	1.0	34.0	27.8	30.1	1.6	31.7	30.1	30.9	0.7	34.9	30.1	32.0	1.9
Barbel lenght 1(upper)	10.9	7.4	9.5	1.1	17.9	10.5	13.1	1.6	13.4	8.6	10.5	1.9	17.0	13.8	15.5	1.2
Barbel lenght 2(lower)	18.5	10.2	12.0	2.0	22.2	13.7	17.2	1.9	19.1	12.7	16.5	2.2	21.5	15.9	19.7	1.7

Table VII.- Meristic features of two pairs barbel species belonging to genus *Capoeta*.

Basin	Dorsal fin unbranched rays	Dorsal fin branched rays	Anal fin branched rays	Ventral fin branched rays
Çoruh	III	$7^{1/2}$-$8^{1/2}$	$5^{1/2}$	8−9
Yeşilırmak	III	$8^{1/2}$	5−$5^{1/2}$	8−9
Kızılırmak	III	$7^{1/2}$-$8^{1/2}$	5,5	8−10
Sakarya	III-IV	8-$9^{1/2}$	5-$5^{1/2}$	8−9
Balcksea	III	$7^{1/2}$-$8^{1/2}$	5−7	8−9
Susurluk	III	8-$8^{1/2}$	5−$5^{1/2}$	7−8
Konya closed	IV	$8^{1/2}$	$5^{1/2}$	8
Lakes region	III	$8^{1/2}$	$5^{1/2}$	8−9
Akdeniz	III	$8^{1/2}$-$9^{1/2}$	$5^{1/2}$	8

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