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Morphometric and meristic characteristics and morphological differentiation among five populations of Brown Trout *Salmo trutta fario* (Pisces: Salmonidae) along the southern Caspian Sea basin

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ABSTRACT

*Morphological characteristics of the native brown trout (*Salmo trutta fario*) from five major rivers of the southern Caspian Sea basin were analyzed using 31 morphometric and 7 meristic characters in order to investigate the hypothesis differentiation and clarify its taxonomic status. Univariate analysis of variance of 162 adult specimens showed significant differences among the means of the five studied groups for 14 standardized morphometric measurements out of 31 characters. In morphometric traits linear discriminant function analysis (DFA), the overall assignments of individuals into their original groups were 60.0% and 55.1% in males and females, respectively. The principal component analysis (PCA), scatter plot of individual component score between PC1 and PC2 showed in male and female specimens grouped into 5 areas in morphometric. The present study indicated that brown trout populations surveyed had high morphologically in the rivers across of the southern Caspian Sea basin that can be considered in conservational policy and restocking programs.*

Keywords: Freshwater Fishes, Salmonidae, Brown Trout, Morphometric Differentiation, Iran

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INTRODUCTION

Brown trout is distributed in a wide area covering a significant part of Europe, the western part of Asia, and the northern part of Africa [1]. The brown trout has three morphologic form including *S. trutta caspius*, living in the sea and migrating in freshwater only to spawn; *S. trutta fario*, residing in freshwater and the lake dwelling form *S. trutta lacustris* [2, 3] that two first subspecies of Brown trout exist in Iran and widely spread in a large number of water streams from the north of Iran, also they are living in the southern Caspian Sea and it's basin that those are endemic in the Caspian Sea basin [4, 5].

Because of ecological and most valuable commercial importance of brown trout, broadly studied is performed; in terms of morphological differentiation [6, 7, 8], morphological variation [9-15], genetic differentiation [16-18], genetic variation [4, 19] and phylogenetic relationship [2, 5, 20-22]. In addition the studies on *S. trutta fario* in Iran are related to the morphological studies [14, 23-24], taxonomy [5, 22], population structure [25, 26], reproduction traits [25], growth and mortality [26, 27] and feeding habits [28, 29]. However, information on population differentiation of brown trout in the southern Caspian Sea basin is still rather limited. In addition, it is important to understand that these populations had morphological differentiation.

Study on fish populations is important from various viewpoints including evolution, ecology, behaviour, conservation, water resource management and stock assessment [30]. Suitable and successful management of aquatic organisms stock will be gained by study of genetic stocks of endemic species and identification of populations [31]. Data on morphometric measurements are able to identify differences between fish populations [32] and used to describe the shape of each fish [33]. In addition, environmental explanation of morphometric differences would contribute to our understanding of life models followed by different local populations, thus helping to develop a sound conservation strategy [8].

Unfortunately, in recent years natural populations of brown trout have been threated because of a permanently increasing anthropogenic impact including mining, over-fishing, poaching, river pollution, destruction of natural spawning areas, drought and forest degradation in the northern part of Iran, where the main spawning rivers of this species are situated [23, 34]. Kiabi *et al*. [35] consider *S. t. fario* to be vulnerable in the southern Caspian Sea basin according to IUCN criteria. The problems of protection and rational use of trout resources cannot be solved without basic information about fish populations in each region and results of this study can be useful for general biological tasks. Studies carried out on the Caspian Sea fishes show that many species possess speciation and population formation microprocess running, as the Caspian and Black seas species [36]. There are several reports on the southern Caspian Sea fishes which indicate the existence of morphological variability in different parts of this basin [37-40]. Considering the above mentioned facts, the present study was i) proposed to use a set of morphometric and meristic characters of native trout populations to analyze potential differentiation of brown trout from the most important rivers of the southern Caspian Sea basins; ii) consider possible implications for their taxonomy and conservation.

MATERIALS AND METHODS

Sampling. A total of 162 individuals of *Salmo trutta* were collected from five sampling sites, one each from Shirinrod (36°9'3.07"N, 53°20'54.65"E; 759 m altitude; 41 individuals), Pajimiana (36°4'13.68"N, 53°16'36.21"E; 1108 m altitude; 31 individuals), Talar (36°3'12.50"N, 53°13'42.32"E; 1377 m altitude; 25 individuals), Babolrod (36°13'1.44"N, 52°38'55.60"E; 481 m altitude; 30 individuals) and Haraz (35°51'43.37"N, 52°7'55.54"E; 1857 m altitude; 35 individuals) rivers, in the southern Caspian Sea Basin (Fig. 1), in the autumn of 2007, by electroshocking with 200-300 V. The sampled fish were fixed in 10% formaldehyde at the sampling sites and transported to the fisheries laboratory for further morphological analyses.

Laboratory Work. Thirty one traditional morphometric characters were measured using a digital caliper to the nearest 0.01 mm (Fig. 2). Also, 7 meristic variables were counted in each specimen by direct observation. The counts and measurements follow Holcik et al. [41]; Samaee et al. [38] and Anvarifar et al., [40]. Measurements were made by the same person. After measuring, fish was dissected to identify the sex of the specimen by macroscopic examination of the gonads. Gender was used as the class variable in ANOVA to test for the significant differences in the morphometric characters if any, between males and females of brown trout.

Data analysis. Size dependent variation was corrected by adapting an allometric method as suggested by Elliott *et al*. [42]

$$M_{adj} = M\,(Ls / L_0)^b$$

Where, M is original measurement, M_{adj} is the size adjusted measurement, L_0 is the standard length of the fish, Ls the overall mean of 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 from both the groups. The results derived from the allometric method were confirmed by testing significance of the correlation between transformed variables and standard length [43].

Univariate Analysis of Variance (ANOVA) was performed for each morphometric character to evaluate the significant difference among the five locations [44] and the morphometric characters which showed significant variation ($P<0.01$) only were used so as to achieve the recommended ratio of number of organisms (N) measured to the parameters (P) included in the analysis to be at least 3-3.5 [45] for obtaining the stable outcome from Multivariate Analysis. In the present study linear discriminant function analyses (DFA), principal component analysis (PCA) and cluster analysis (CA) were employed to discriminate the five populations. The Wilk's lambda was used to compare the difference among all groups. The DFA was used to calculate the percentage of correctly classified (PCC) fish. A cross-validation using PCC was done to estimate the expected actual error rates of the classification functions. As a complement to discriminant analysis, morphometric distances between the individuals of five groups were inferred to Cluster analysis [46] by adopting the Euclidean square distance as a measure of dissimilarity and the UPGMA (Unweighed Pair Group Method with Arithmetical average) method as the clustering algorithm [47].

Statistical analyses for morphometric data were performed using the SPSS version 16 software package, Numerical Taxonomy and Multivariate Analysis System (NTSYS-pc) [48] and Excel (Microsoft office, 2012).

RESULTS

Descriptive data for the morphometric characters and range (Minimum-Maximum), mean, standard deviation (SD) of length and weight in case of sampled specimens is shown in Table 1 & 2. Different physic-chemical parameters of the five studied rivers in the southern Caspian Sea basin is shown in table 8. The correlation between transformed morphometric variables and standard length was non-significant ($p>0.05$) that confirm size or allometric signature on the basic morphological data was accounted. Differences ($P<0.05$) among the five populations of brown trout in the Shirinrod, Pajimiana, Talar, Babolrod and Haraz rivers in the southern Caspian Sea basin were observed for 14 out of 31 morphometric characters (Table 3) and these significant variables were used further for multivariate analysis (PCA, DFA and CA).

The ANOVA revealed effective morphologic characters on sexual dimorphism ($p<0.05$) in 18 of the 31 studied morphometric measurements (Table 4). Therefore, the analyses of morphometric characters were conducted with the sexes separated.

In order to determine which morphometric measurement most effectively differentiates populations, the contributions of variables to principal components (PC) were examined. To examine the suitability of the data for PCA, Bartlett's Test of sphericity and Kaiser-Meyer-Olkin (KMO) measure was performed. In this study for morphometric characters, the values of KMO for overall matrix are 0.582 and 0.701 in males and females, respectively. The Bartlett's Test of Sphericity is significant ($P\leq0.01$). The results (KMO and Bartlett's) suggest that the sampled data is appropriate to proceed with a factor analysis procedure. In order to determine which morphometric measurement made most effectively differentiates among the populations, the contributions of variables to principal components (PC) were examined.

Principal component analysis of 14 morphometric measurements extracted five factors with eigenvalues >1 for morphometric traits, explaining 66.8% and 75.3 of the variance in male and female, respectively (Table 5). The first principal component (PC1) accounted for 23.7% and 28.5% of the variation and the second principal component (PC2) for 14.9% and 19.6% in males and females, respectively (Table 5). The most significant loadings on PC1 and PC2 in males were TJ, FF', ES and in females were XX', TJ, LR, DD', AA', FF'.

Visual examination of plots of PC1 and PC2 scores in morphometric characters revealed that the 162 specimens grouped into 4 areas in female and 2 areas in male with high degree of overlap among the five populations that this overlap in male is more than female (Fig. 3).

In PCA the characteristics with an eigenvalues exceeding 1 were included and others discarded. It is worth mentioning out here that factor loading greater than 0.30 are considered significant, 0.40 are considered more important and 0.50 or greater are considered very significant [49]. For parsimony, in this study only those factors with loadings above 0.7 were considered significant.

The Wilks' lambda tests of discriminant analysis indicated significant differences in morphometric characters of the five populations. In this test, seven functions were highly significant ($P\leq0.01$) and four functions were non-significant ($p>0.05$) (Table 7). In morphometric traits linear discriminant function analysis (DFA), the overall assignments of individuals into their original groups were 60.0% and 55.1% in males and females, respectively (Table 6).

In both of male and female the cross-validation testing procedure were exactly the same as PCC results. Figure 4 indicates the coordinates of the five populations in the two first axes of DFA. In this analysis there was a medium degree of separation among brown trout specimens in the southern Caspian Sea. In morphometric characters coordinate plot for different sexes of brown trout specimens according to the first two discriminant functions revealed specimens grouped into 5 areas with low degree of overlap among the five populations that this overlap in male is more than female (Fig. 4). The measurements that used in this analysis in morphometric characters for males included LC, PV and for females were LC, LR, RO, DL, FF', SM.

Clustering analysis based on Euclidean distances in morphometric characters among the groups of centroids using an UPGMA in males resulted into two main clusters Shirinrod, Pajimiana and Talar in one group and Babolrod and Haraz in other group. Also, in females the populations were clustered in two distinct clads, the first one consists of Shirinrod and Pajimiana and second clad includes Talar, Babolrod and Haraz populations, although they are far apart geographically.

DISCUSSION

The results of the present study revealed that brown trout populations surveyed had high morphologically and there are at least three distinct morphologic forms using traditional methods. Some related morphological studies have been recently done in the region on the native fishes [50-53]. The analysis of variance revealed significant phenotypic variation among the five native populations of brown trout in the southern Caspian Sea basin (Table 3). Discriminant Function Analysis could be a useful method to distinguish different stocks of a same species [9]. In the present study, 55-60%% in morphometric, individuals were correctly classified in to their respective groups by DFA that indicating a low to moderate differentiation between the populations of brown trout in the studied areas, as the proportion of individuals correctly classified into their original groups in some stations was below of 50% e.g. Pajimiana, Talar and Haraz populations in morphometric male); Pajimiana and Babolrod in morphometric (female); (Table 5). This moderate segregation was partly confirmed by PCA, where the graphs of PC1 and PC2 scores for each sample in morphometric (Fig. 3) revealed that five populations were distinct from each other with high degree of overlap while in meristic populations were divided to three areas in male.

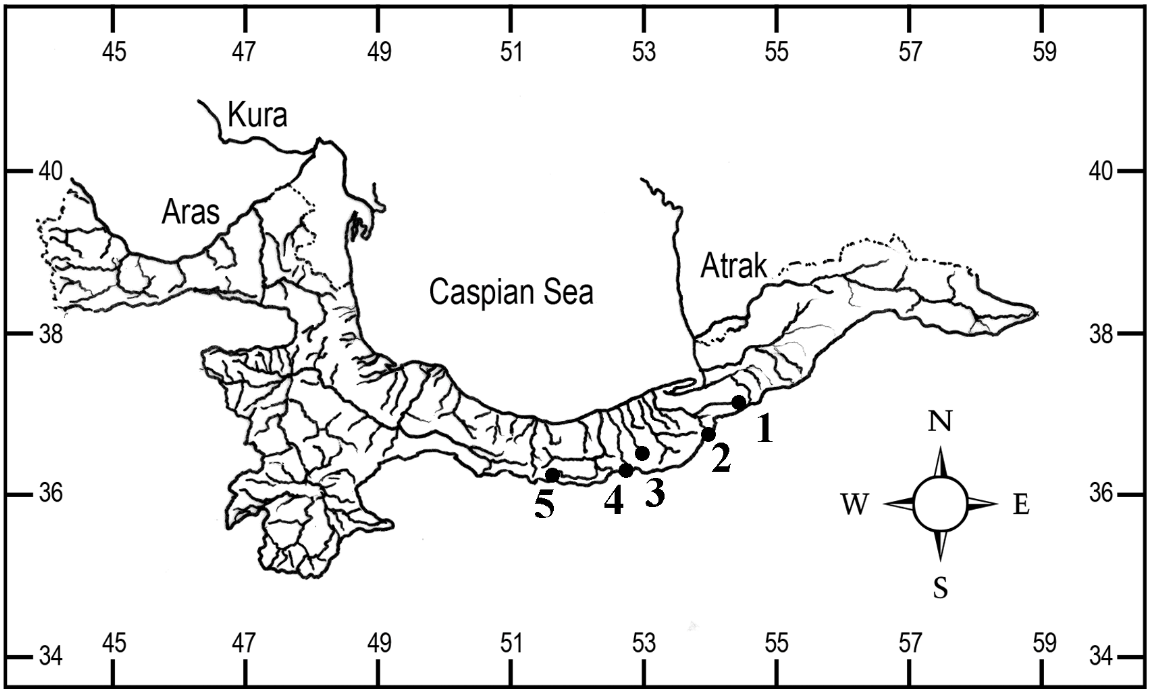

Figure 1. Location of sampling sites for brown trout populations including 1) Shirinrod, 2) Pajimiana, 3) Talar, 4) Babolrod and 5) Haraz in the southern Caspian Sea Basin

The causes of morphological differences between populations are often quite difficult to explain [54]. It has been suggested that the morphological characteristics of fish are determined by genetic, environment and the interaction between them [54-56]. The environmental factors prevailing during the early development stages, when individual's phenotype is more amenable to environmental influence is of particular importance [56]. Accordingly, some experiments have demonstrated that, in brown trout, variations in body shape can persist after a "commongarden" rearing (Pakkasmaa & Piironen, 2001). The phenotypic variability may not necessarily reflect population differentiation at the molecular level [57]. In this study physic-chemical parameters are approximately the same in the studied rivers (Table 7) and probably this similar environment conditions causes similar morphologically populations.

It is well known that morphological characteristics can show high plasticity in response to differences in environmental conditions [58]. Therefore, the distinctive environmental conditions of studied areas may underline the morphological differentiation among these stations. Differentiation between samples from adjacent stations may be due to the geographic isolation. The influences of environmental parameters on morphometric characters are well discussed by several authors in the course of fish population segregation [37, 40, 55]. These morphological differences may be solely related to body shape variation and not to size effects which were successfully accounted for by allometric transformation. On the other hand, size related traits play a predominant role in morphometric analysis and the results may be erroneous if not adjusted for statistical analyses of data [59]. In the present study, the size effect had been removed successfully by allometric transformation, and the significant differences between the populations are due to the body shape variation when it tested using ANOVA and multivariate analysis.

Novikov *et al*. [60] and Vera *et al*. [34] examined allozyme variability in trout populations from Iran and found them to be similar but diverging significantly from other populations in the Caspian Sea basin. Shirangi *et al*. [61] used microsatellite DNA to compare spring and fall migratory forms in Iran and they found low genetic differentiation and conclude that only one population exists in the southern Caspian Sea. Bernatchez [62] considers all Caspian trout to belong to the Danubian or Ponto-Caspian lineage, one of five lineages, and that the centre of origin was probably from drainages associated with the Caucasus region of the Black Sea. Hashemzadeh Segherloo *et al*. [3] used DNA and morphology to compare south Caspian, Orumiyeh and Namak populations and they concluded that the Caspian and Orumiyeh populations did not differ significantly but the Namak population represented a unique haplotype. Also, they stated all haplotypes fell within the Danubian phylogenetic grouping as distinct members and the Namak haplotype may have a centre of origin in the Caspian basin. Considering the above mentioned findings it seems brown trout samples that studied in this survey belong to the Danubian lineage.

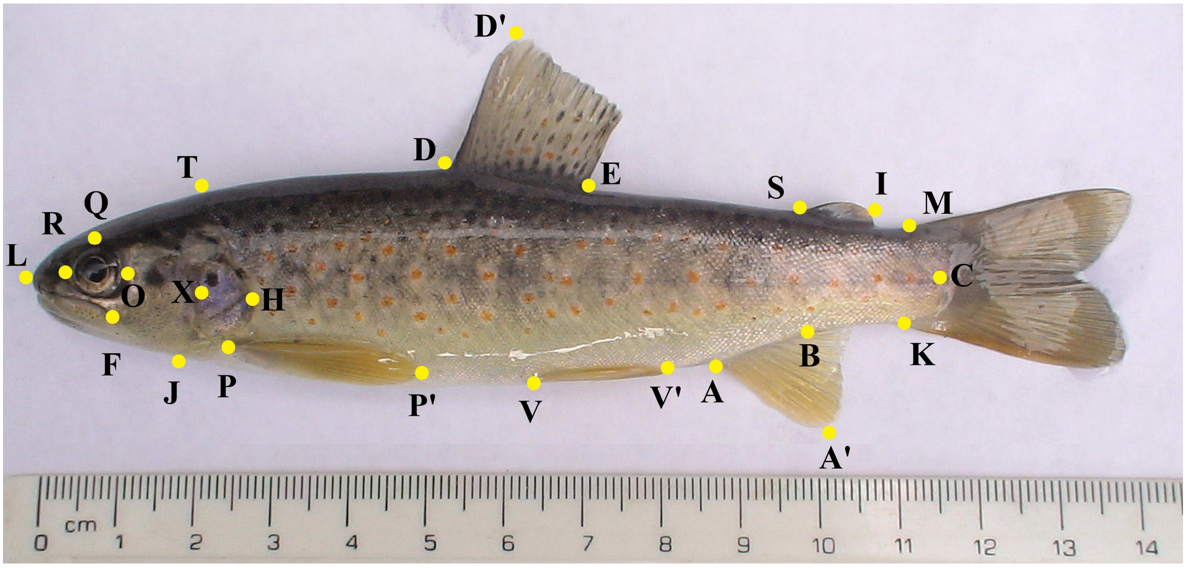

Figure 2. Morphometric characters measured on Brown trout, *Salmo trutta fario*, samples from the rivers of Southern Caspian Sea Basin. Landmarks selected based on studies of S Holcik et al. 1989; Samaee et al. 2009 and Anvarifar et al., 2013. LC: standard length, D↓: Body Width, BC: caudal peduncle length, B↑: caudal peduncle depth, LH: Head Length, XX': Head Width, TJ: Head Depth, LR: Snout length (preorbital distance), RO: Eye diameter, OH: postorbital distance, QQ': Interorbital distance, DL: Predorsal distance, EM: Postdorsal distance, LV: Prepelvic distance, VK: Postpelvic distance, LA: Preanal distance, BK: Postanal distance, DE: Dorsal Fin base, DD': Dorsal Fin length, AA': Anal Fin length, AB: Anal Fin base, PP': Pectoral Fin length, VV': Pelvic Fin length, PV: Pectoral-ventral distance, FF': Mouth Width, SI: adipose fin length, ES: Dorsal-adipose distance, SM: caudal-adipose distance, LF: premaxilla length, γγ': maxilla width, μμ': lower jaw length.

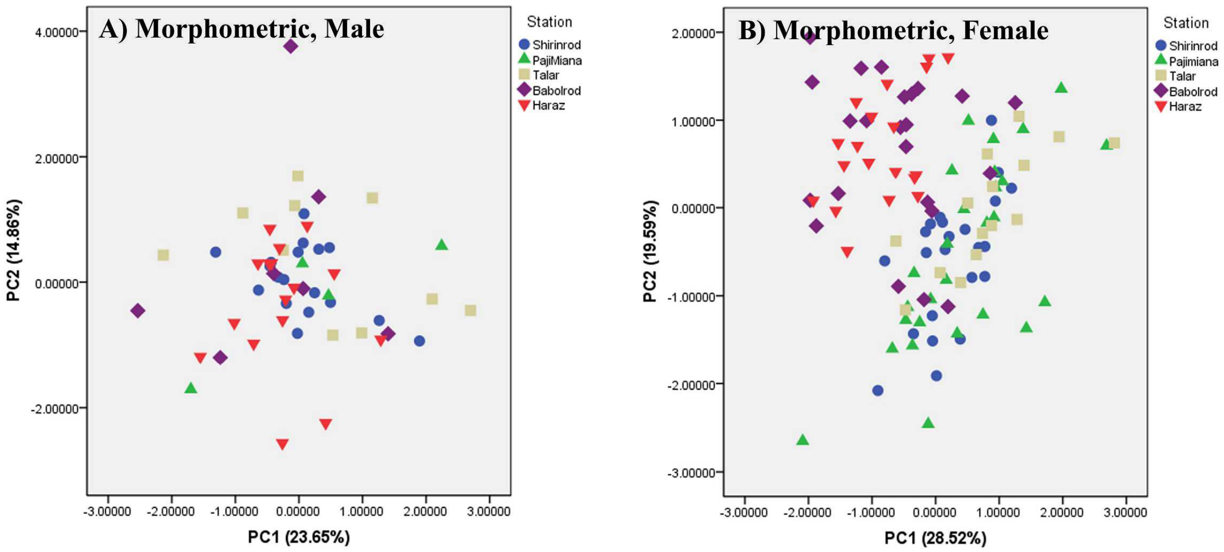

Figure 3. Plot of the factor scores for PC1 and PC2 of morphological traits for different sexes of brown trout populations in the rivers of southern Caspian Sea basin.

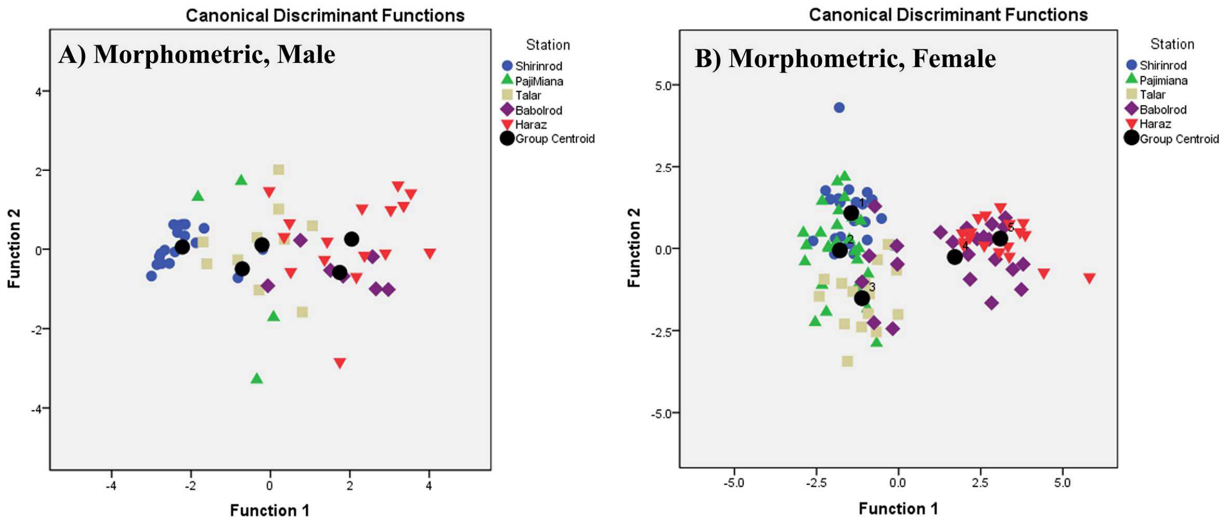

Figure 4. Coordinate plot for different sexes of brown trout specimens according to the first two discriminant functions from morphometric data analysis in the rivers of southern Caspian Sea basin

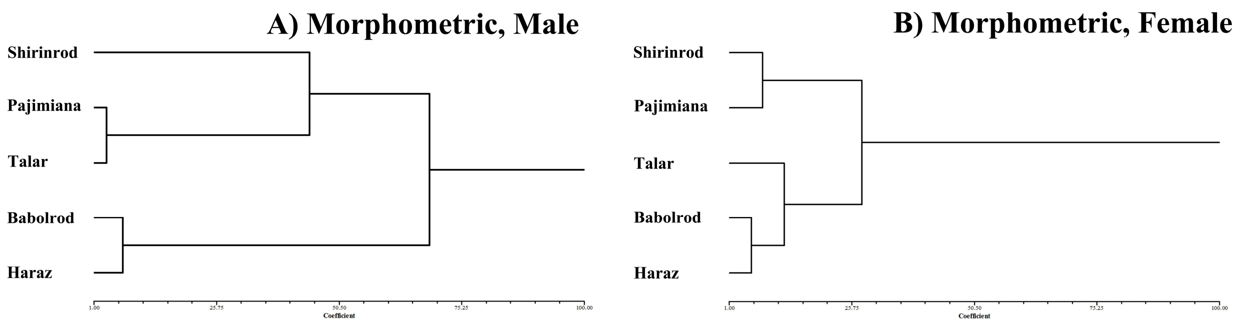

Figure 5. Dendrogram derived from cluster analyses of 14 traits in morphometric traits on the basis of Euclidean distance for brown trout populations.

Table 1. Descriptive data of morphometric characters of brown trout samples among stations sampling sites including Shirinrod, Pajimiana, Talar, Babolrod and Haraz in the south Caspian Sea basin

Traits	Minimum	Maximum	Mean	Std. Deviation
standard length	64.48	266.12	116.2202	41.84690
Body Width	15.84	45.12	26.9316	8.64025
caudal peduncle length	12.83	33.07	20.0724	4.61290
caudal peduncle depth	7.02	21.75	11.7160	3.26374
Head Length	15.95	51.04	30.7884	8.55809
Head Width	7.54	26.05	15.1564	4.26441
Head Depth	12.55	30.67	18.8582	4.00649
Snout length	4.67	13.32	7.3489	2.21358
Eye diameter	5.35	14.37	7.8964	1.72179
postorbital distance	4.67	13.32	7.3489	2.21358
Interorbital distance	4.37	16.96	9.0188	2.77341
Predorsal distance	33.24	84.22	52.8529	14.71211
Postdorsal distance	3.91	74.25	48.2078	12.43192
Prepelvic distance	35.74	101.37	62.6735	18.05625
Postpelvic distance	34.09	82.57	52.6604	13.77992
Preanal distance	56.96	134.97	85.5486	24.22054
Postanal distance	7.55	32.94	20.0313	4.79714
Dorsal Fin base	8.67	73.70	17.0026	7.06042
Dorsal Fin length	16.46	39.17	23.6965	5.72590
Anal Fin base	7.29	21.08	12.3320	3.77869
Anal Fin length	12.57	33.77	20.9951	5.37318
Pectoral Fin length	16.32	37.19	23.9978	5.27967
Pelvic Fin length	12.05	28.69	17.6554	4.35191
Pectoral-ventral distance	23.26	66.55	37.8309	11.87018
Mouth Width	6.35	22.93	11.8046	3.57510
adipose fin length	2.39	8.94	4.7822	1.44308
Dorsal-adipose distance	11.66	30.22	21.1962	5.52518
caudal-adipose distance	12.48	44.03	22.3104	8.71375
premaxilla length	7.24	23.98	12.1604	3.55571
maxilla width	1.95	12.84	3.2162	1.03065
lower jaw length	6.13	30.90	16.7794	4.88605

Table 2. Descriptive data of brown trout samples including length (mm) and weight (gr) from the different rivers of Southern Caspian Sea Basin.

Smaple	Sex	N	Min-Max (length)	Mean± S.D. (length)	Min-Max (weight)	Mean± S.D. (weight)
Shirinrod	Male	18	91.62-157.36	118.72±18.37	16.04-74.14	33.41±16.13
	Female	23	84.32-266.12	117.39±35.70	10.63-390	41.23±76.72
Pajimiana	Male	4	91.54-98.58	93.73±3.26	14.56-18.67	16.23±1.73
	Female	27	79.7-215.12	100.18±34.23	9.11-181.54	27.06±40.82
Talar	Male	10	69.08-94.10	84.69±6.69	4.38-11.56	8.46±1.85
	Female	15	64.48-92.86	76.73±7.58	3.63-11.42	6.13±2.18
Babolrod	Male	7	87.58-137.68	111.35±21.30	12.05-45.01	25.12±14.59
	Female	23	13.08-124.56	87.15±21.68	6.73-40.70	15.08±10.22
Haraz	Male	16	110.60-225.80	178.56±35.09	19.25-239.67	112.41±72.20
	Female	19	100.20-235.78	168.13±36.94	20.15-251.95	110.62±64.07

Table 3. Results of ANOVA of morphometric characters of brown trout samples among stations sampling sites including Shirinrod, Pajimiana, Talar, Babolrod and Haraz in the south Caspian Sea basin

Traits	F value	P value	Traits	F value	P value	Traits	F value	P value	Traits	F value	P value
LC	2.79	0.03	**RO**	3.42	0.01	**BK**	0.87	0.48	**FF'**	11.96	0.00
D↓	3.40	0.01	**OH**	1.03	0.40	**DE**	3.73	0.01	**SI**	1.65	0.17
BC	1.16	0.33	**QQ'**	1.15	0.34	**DD'**	5.21	0.00	**ES**	16.48	0.00
B↑	1.79	0.13	**DL**	9.20	0.00	**AB**	1.80	0.13	**SM**	21.03	0.00
LH	1.17	0.32	**EM**	0.95	0.44	**AA'**	2.89	0.02	**LF**	2.22	0.07
XX'	4.73	0.00	**LV**	1.07	0.37	**PP'**	1.47	0.21	**γγ'**	1.37	0.25
TJ	7.16	0.00	**VK**	2.24	0.07	**VV'**	1.27	0.29	**μμ'**	1.97	0.10
LR	11.31	0.00	**LA**	2.04	0.09	**PV**	5.73	0.00			

Table 4. Results of ANOVA for sex dimorphism of morphometric characters of brown trout from different rivers of southern Caspian Sea basin

Traits	F value	P value	Traits	F value	P value	Traits	F value	P value	Traits	F value	P value
LC	39.14	0.00	**RO**	7.32	0.01	**BK**	0.84	0.36	**FF'**	10.33	0.00
D↓	0.45	0.50	**OH**	6.19	0.01	**DE**	1.91	0.17	**SI**	1.55	0.21
BC	2.01	0.16	**QQ'**	1.22	0.27	**DD'**	4.63	0.03	**ES**	92.14	0.00
B↑	2.75	0.10	**DL**	7.98	0.01	**AB**	4.85	0.03	**SM**	73.53	0.00
LH	0.27	0.60	**EM**	5.30	0.02	**AA'**	4.61	0.03	**LF**	2.74	0.10
XX'	8.38	0.00	**LV**	2.59	0.11	**PP'**	4.29	0.04	**γγ'**	0.12	0.73
TJ	10.04	0.00	**VK**	7.36	0.01	**VV'**	7.22	0.01	**μμ'**	11.61	0.00
LR	0.30	0.59	**LA**	0.15	0.70	**PV**	18.74	0.00			

Table 5. Eigenvalues, percentage of variance and percentage of cumulative variance for the principal components in case of morphometric traits in different sexes for brown trout samples from the different rivers of southern Caspian Sea basin.

Factor	Male			Female		
	Eigenv.	Per. of variance	Per. of Cu. vari.	Eigenv.	Per. of variance	Per. of Cu. vari.
PC1	3.3	23.7	23.7	4.0	28.5	28.5
PC2	2.1	14.9	38.5	2.7	19.6	48.1
PC3	1.7	11.8	50.3	1.5	10.8	58.9
PC4	1.2	8.6	59.0	1.2	8.8	67.7
PC5	1.1	7.8	66.8	1.1	7.6	75.3

Table 6: Percentage of specimens classified in each group and after cross validation for morphometric data in different sexes.

			Male					Female				
		Station	Shirinrod	Pajimiana	Talar	Babolrod	Haraz	Shirinrod	Pajimiana	Talar	Babolrod	Haraz
Cross Validated	**Count**	Sh.	16	1	1	0	0	15	7	1	0	0
		Pa.	1	0	2	1	0	8	10	9	0	0
		Ta.	2	2	4	1	1	1	3	11	0	0
		Ba.	0	1	1	4	1	2	1	4	8	8
		Ha.	0	0	4	3	9	0	0	0	4	15
	%	Sh.	88.9	5.6	5.6	0.0	88.9	65.2	30.4	4.3	0.0	0.0
		Pa.	25.0	0.0	50.0	25.0	25.0	29.6	37.0	33.3	0.0	0.0
		Ta.	20.0	20.0	40.0	10.0	20.0	6.7	20.0	73.3	0.0	0.0
		Ba.	0.0	14.3	14.3	57.1	0.0	8.7	4.3	17.4	34.8	34.8
		Ha.	0.0	0.0	25.0	18.8	0.0	0.0	0.0	0.0	21.1	78.9

Table 7. Result of Wilks' lambda test for verifying difference among five populations of in different sexes for brown trout samples when morphological measurements are separately compared using discriminant Function analysis.

	Test of Functions	Wilks' Lambda	Chi-square	Df	Sig.
Male	1 through 2	0.20	81.36	8	0.000
	2	0.92	4.43	3	0.219
Female	1 through 4	0.11	223.83	24	0.000
	2 through 4	0.53	63.27	15	0.000
	3 through 4	0.87	14.06	8	0.080
	4	0.98	2.53	3	0.471

Table 8. Different physic-chemical parameters of three rivers of south Caspian Sea basin in autumn of 2007.

Parameter / Station	pH (Mean± S.D.)	T (°C) (Mean± S.D.)	Sal (‰) (Mean± S.D.)	TDS mg l^{-1} (Mean± S.D.)	Con (μS/cm) (Mean± S.D.)
Shirinrod	8.38±0.1	12.9±0.93	0.3±0.03	266.31±6.01	538±16.52
Pajimiana	8.52±0.1	11.22±0.96	0.21±0.04	173.6±6.24	375.66±14.32
Babolrod	8.56±0.1	13.58±1.04	0.21±0.04	169.76±6.91	342.0±16.85

CONCLUSION

In conclusion, the present study indicates that the studied populations are similar together in morphometric and meristic and there are at least three distinct populations of brown trout in the studied areas. A detailed study involving the molecular genetics and environmental aspects may further confirm the present findings unambiguously. Also, in order to have better conservational policy and restocking programs, further studies are recommended on determining other possible populations of this species in other regions of the Caspian Sea. Present study provides basic information about the morphometric variation and differentiation of *S. trutta fario* populations in the southern Caspian Sea Basin and it suggests that morphological variations observed in *S. trutta fario* should be considered in fisheries management and commercial exploitation of this species.

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