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Morphometric and meristic characteristics of Hemiculter leucisculus (Teleostei:Cypryniformes) population in the Haraz River Basin (Southern Caspian Sea)

Abstract

Morphometric and meristic characteristics of *Hemiculter leucisculus* population were studied in the Haraz River ecosystem in spring 2021, examining 27 morphometric and 10 meristic characteristics on 100 fish caught using a gillnet. According to the results, the mean coefficients of variation were 18.144% and 10.548% in females and 17.669% and 10.714% in males for morphometric and meristic characteristics, respectively. Morphometric data were standardized before analyses to reduce the error due to allometric growth. In morphometric variables, ten factors were separated, representing 73.831% of the phenotypic variations; further, three factors were selected from meristic variables, denoting 62.838% of the phenotypic variations. The results of t-test analyses showed significant differences in 3 morphometric characteristics out of 34 morphometric and meristic characteristics of male and female fish ($P \leq 0.05$). There was an overlap between the results obtained by Principal Component Analysis concerning morphometric and meristic characteristics of male and female fish, making it impossible to separate these two sexes according to the studied characteristics.

Keywords: fish carp, morphological characteristics, principal component analyze, Caspian sea

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Introduction

The study of morphological characteristics aimed at defining and identifying population units has a long history in the science of fish biology.[1] Morphological differences are the result of both genetic and environmental factors and the interaction between the two.[2] The morphological flexibility of fish allows them to respond to environmental changes through physiological and behavioral alterations that can, in turn, lead to morphometric, reproductive, and survival changes, modulating the effects of environmental changes.[3,4] These morphological changes do not necessarily lead to genetic alterations of the population.[5,6] Morphometric and meristic indices are widely used in the systematic study of different fish populations and the separation of fish species from each other.[7] Morphometric and meristic characteristics are an effective method to identify, separate, or overlap different populations and the first step in assessing the population structure of a species.[8]

Hemiculter leucisculus is one of the species of carp family in Iran, with a maximum standard length of up to 175 mm. It is most abundant in the Southern Caspian Sea basin and the Anzali Lagoon. This species is non-native to Iran and belongs to freshwater fish, but it also tolerates low salinity and is often on the surface of the water. This fish feeds on phytoplankton, zooplankton, and aquatic insects, while adults feed on the eggs of other fish and even young fish, having a wide variety of food. These fish mature at the age of 2-3 years.[9]

This study aimed to investigate the morphological and meristic characteristics of male and female *Hemiculter leucisculus* in the Haraz River basin.

Materials and methods

Fish sampling was performed from the Haraz River in the Sorkhrud region, which leads to the Caspian Sea, in spring 2021 using a gillnet (Figure 1). The studied area is located at the geographical coordinates of E: 52° 27′ 28″ and N: 36° 40′ 38″.

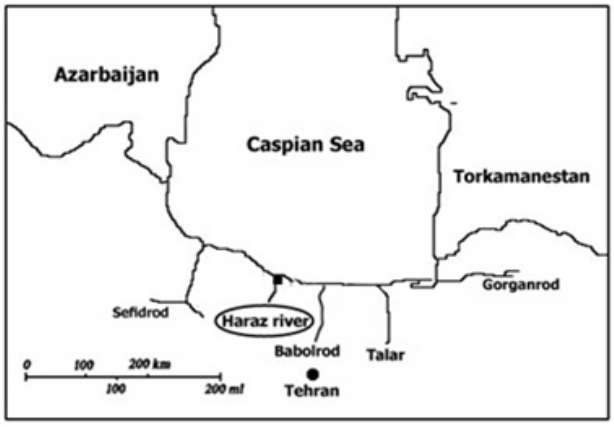

Figure 1 Location map of the Haraz River in the Mazandaran Province, Iran.

Overall, 100 *Hemiculter leucisculus* fish were caught, fixed in 10% formalin, and transferred to the laboratory of the Research Center for the Caspian Region, University of Mazandaran. The 27 morphometric characteristics under study (Table 1). Morphometric data were standardized by the Beacham formula before analysis. Standardizing morphometric data will reduce the changes resulting from allometric growth.[10]

$$M_{(t)} = M_{(0)}\left(\frac{L}{L_{(0)}}\right)^{b}$$

$M_{(t)}$: Standardized values of characteristics, $M_{(0)}$: The length of observed characteristics

L : Average standard length for the total sample and for all regions, $L_{(0)}$: Standard length of each sample, b : Regression coefficient between $Log\, M_{(0)}$ and $Log\, L_{(0)}$ for each region

Mean, standard deviation, and multivariate coefficients of variation of all morphometric and meristic characteristics were calculated for morphological diversity.[11]

$$C.V_p = 100\sqrt{\frac{\sum S^2}{\sum X^2}}$$

S^2 : Variance of characteristics under study, X^2 : Mean square of the same characteristics under study.

T-test was used to determine the differences between the studied sexes in each of the characteristics. The matrix relationship of morphological characteristics was examined using factor analysis and principal component analysis (PCA), identifying the main characteristics out of the ones extracted. The above calculations were performed using SPSS (26) and EXCEL statistical (2019) software.

Results

The mean values of coefficient of variation (CV) were 18.144% and 10.584% for the female and 17.669% and 10.714% for the male *Hemiculter leucisculus* fish in terms of morphometric and meristic characteristics, respectively. The mean coefficient of variation of morphometric and meristic characteristics of these two sexes showed close values for both characteristics (Table 1 and 2).

Table 1 Mean, SD, Min, Max, and CV of morphometric characteristics of male and female *Hemiculter leucisculus* (mm)

CV%		Average ± SD Min - Max	Average ± SD Min - Max	Variables
Male	Female	Male	Female	
16.485	16.234	152.515±25.143 100–190	143.898±23.361 100–186	Total length
15.987	16.488	137.751±22.023 90.9- 172	130.601±21.534 90- 170	Fork length
16.068	15.888	123.317±19.815 83.8- 155	116.637±18.532 81.65- 152	Standard length
13.726	14.799	28.019±3.876 19.75- 33.2	26.846±3.973 19.85–36	Head length
17.838	19.048	13.813±2.464 8.5–19.95	13.056±2.487 9.3–17.85	Head width
15.588	18.379	19.777±3.083 13.4–26.1	18.450±3.391 11.55–24.75	Head depth
19.266	19.436	29.455±5.675 15.6–39	27.948±5.432 17.65- 40	Max depth body
20.394	25.625	11.464±2.338 5.9- 15.2	10.584±2.703 4.2- 19.75	Min depth body
16.849	18.533	8.19±1.380 5.15–11.15	7.980±1.479 5–11.85	Snout length
14.788	15.151	6.647±0.983 8.8–4.4	6.600±1.000 4.6–8.55	Eye diameter
16.934	17.492	8.834±1.496 5.95- 11.6	8.495±1.486 5.35- 11	Distance between eyes
15.830	19.683	14.245±2.255 10- 18.5	13.453±2.648 9- 18.55	After-eye length
21.262	20.689	18.225±3.875 11.4-26.7	17.400±3.600 10-24.75	Caudal peduncle length
23.903	17.453	12.475±2.982 7.7–25.25	11.992±2.093 8.7–15.95	Dorsal fin length
18.570	20.891	18.422±3.421 11.7- 25.75	17.112±3.575 10.65- 26.1	Dorsal fin depth
15.656	15.755	66.887±10.472 45.1–83.2	63.982±10.081 47–81.7	Pre-dorsal length
20.156	20.035	46.129±9.298 29.75- 75.2	44.192±8.854 24.95- 59.15	Post-dorsal length
19.467	17.801	15.652±3.047 9–24	14.617±2.602 10.6- 20	Anal fin length
18.043	18.985	13.384±2.415 9–18	12.710±2.413 8.2- 18.1	Anal fin depth
17.016	16.159	90.226±15.353 43.6- 113.9	86.35±13.954 56.45- 114.3	Pre-anal length

Table 1 Continued....

CV%		Average ± SD Min - Max	Average ± SD Min - Max	Variables
Male	**Female**	**Male**	**Female**	
21.262	20.656	18.225±3.875 11.4- 26.7	17.210±3.555 10- 24.75	Post-anal length
15.039	16.543	25.886±3.893 17.9- 33.7	24.197±4.003 17.45- 31.35	Pectoral fin length
18.260	17.538	18.362±3.353 11.7- 23.75	17.151±3.008 12.8- 22.5	Ventral fin length
14.495	15.466	63.137±9.152 42.6- 78.7	60.287±9.324 40–79	Pre-ventral length
18.737	17.484	63.268±11.855 36.45- 81.2	60.093±10.507 41–80.6	Post-ventral length
18.175	16.721	35.41±6.436 22.1- 49.5	33.956±5.678 22.65- 45	Pectoral-ventral length
17.278	20.962	31.386±5.423 18.75- 39.45	29.701±6.226 18.5–43.05	Ventral-anal length
CV%		SD		Average
Male	Female	Male	Female	
17.669	18.144	6.865	6.574	

Table 2 Mean, SD, Min, Max, and CV of meristic characteristics of male and female *Hemiculter leucisculus*

CV%		Average ± SD Min - Max	Average ± SD Min - Max	Variables
Male	Female	Male	Female	
20.360	18.268	2.333±0.475 2-3	2.195±0.401 2-3	Hard rays of dorsal fin
8.958	7.652	7.166±0.642 5-8	7.292±0.558 6-8	Soft rays of dorsal fin
19.377	20.328	2.250±0.436 2-3	2.317±0.471 2-3	Hard rays of anal fin
6.077	7.060	11.650±0.708 11-13	11.756±0.830 11-13	Soft rays of anal fin
8.201	7.055	15.350±1.259 14-18	16.341±1.153 15-18	Brushed gill outer
6.041	6.091	19.283±1.165 18-21	19.439±1.184 18-21	Brushed gill inner
4.093	4.813	52.300±2.141 49-56	52.024±2.504 49-56	Lateral line
11.259	11.463	9.9450±1.064 8-11	9.561±1.096 8-11	Lateral line up
20.562	19.873	2.383±0.490 2-3	2.536±0.504 2-3	Down lateral line
2.217	2.878	36.750±0.815 35-38	36.512±1.051 35-38	Number of vertebrae
CV%		SD		Average
Male	Female	Male	Female	
10.714	10.548	0.919	0.975	

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T-test for 27 morphometric and 10 meristic characteristics of male and female fish. According to this test, male and female fish had significant differences in 3 morphologic characteristics of head depth, dorsal fin depth, and pectoral fin base length (P≤0.05), but there were no significant differences in 24 morphometric and all meristic characteristics (P>0.05) (Table 3).

Table 3 The results of the t-test for morphometric and meristic characteristics of male and female *Hemiculter leucisculus*

P value	F computational	Characteristics examined
0/05>	0.088	Total length
0/05>	0.003	Fork length
0/05>	0.214	Standard length
0/05>	0.154	Head length
0/05>	0.136	Head width
0/05<*	0.448	Head depth
0/05>	0.059	Max depth body
0/05>	0.327	Min depth body
0/05>	0.008	Snout length
0/05>	0.378	Diameter Eye
0/05>	0.050	Distance between eyes
0/05>	1.548	After-length eye
0/05>	0.207	Caudal peduncle length
0/05>	1.495	Dorsal fin length
0/05<*	0.033	Dorsal fin depth
0/05>	0.001	Pre-dorsal length
0/05>	0.176	Post-dorsal length
0/05>	0.312	Anal fin length
0/05>	0.086	Anal fin height
0/05>	0.185	Pre- anal length
0/05>	0.285	Post-anal length
0/05<*	0.189	Pectoral fin length
0/05>	0.405	Ventral fin length
0/05>	0.107	Pre-ventral length
0/05>	0.679	Post-ventral length
0/05>	0.657	Pectoral-ventral length
0/05>	1.338	Ventral-anal length
0/05>	10.571	Hard rays of dorsal fin
0/05>	0.580	Soft rays of dorsal fin
0/05>	6.638	Hard rays of anal fin
0/05>	1.842	Soft rays of anal fin
0/05>	1.648	Brushed gill outer
0/05>	1.573	Brushed gill inner
0/05>	1.551	Lateral line
0/05>	0.071	Lateral line up
0/05>	1.757	Down lateral line
0/05>	6.141	Number of vertebrae

Linear combination of 27 morphometric and 10 meristic characteristics using Principal Component Analysis (PCA) leads to factors that show certain features of the relationship between characteristics. Hence, the higher the variance of a factor is, the higher the participation coefficient of that factor will be in the separation of populations. Factor analysis of morphometric characteristics led to the selection of 10 factors with eigenvalues of >1, explaining 73.83% of the variance of characteristics (Table 4).

Table 4 Eigenvalues, percentage of variance, and extracted factors of morphometric characteristics of male and female *Hemiculter leucisculus*

%Cumulative	ofVariance%	Eigen value	Component
10.767	10.767	2.907	1
20.380	9.613	2.596	2
29.376	8.996	2.429	3
38.298	8.922	2.409	4
45.437	7.139	1.928	5
52.074	6.637	1.792	6
58.522	6.448	1.741	7
64.422	5.900	1.593	8
70.087	5.664	1.529	9
73.831	3.744	1.011	10

Pre-anal length and ventral anal length, ventral fin length, anal fin depth, caudal peduncle length and post-anal length, and after-eye length had factor coefficients of >0.75 in the first to the fifth factors, respectively. No characteristics had a factor coefficient of >0.75 in the sixth and ninth factors. Eye diameter, head width, and standard length had factor coefficients of >0.75 in the seventh, eighth, and tenth factors, respectively (Figure 2).

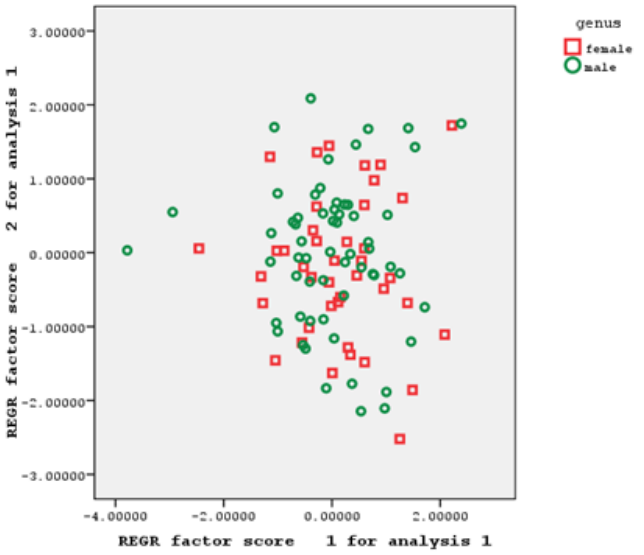

Figure 2 Individual distribution based on the first and second factors of morphometric characteristics of male and female *Hemiculter leucisculus*.

Factor analysis for meristic characteristics led to the selection of 3 factors with eigenvalues greater than 1, explaining 62.83% of the variance of characteristics (Table 5).

Table 5 Eigenvalues, percentage of variance, and extracted factors of meristic characteristics of male and female *Hemiculter leucisculus*

%Cumulative	ofVariance%	Eigen value	Component
23.269	23.269	1.629	1
43.828	20.559	1.439	2
62.838	19.009	1.331	3

Brushed gill outer and brushed gill inner from the first factor, hard rays of the anal fin from the second factor, and the soft rays of the anal fin from the third factor had factor coefficients of >0.75 (Figure 3).

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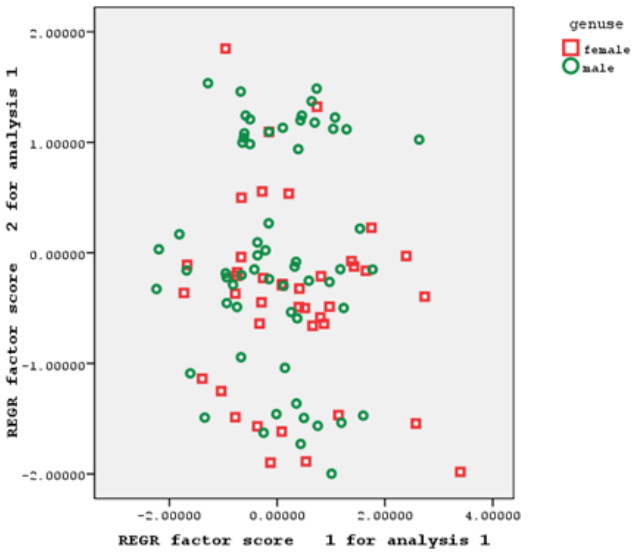

Figure 3 Individual distribution based on the first and second factors of meristic characteristics of male and female *Hemiculter leucisculus*.

As the individual distribution based on the relationships of the first and second extracted factors of morphometric and meristic characteristics shows, the two sexes understudy had a significant overlap in terms of morphometric characteristics (with only a few number of samples separated from each other), making it impossible to separate male and female fish based on these characteristics (Figure 2). These two sexes also had a relatively high overlap in terms of meristic characteristics, which could not be a factor for the separation of the two sexes of fish (Figure 3).

Discussion

There were high levels of intrapopulation variation based on the total coefficient of variation, which could be due to three factors of heterogeneous growth, the presence of more than one population in the region, and the presence of different phenotypic groups in the study area. Data standardization considerably reduces the effect of allometric growth, and it is possible to avoid the presence of different populations by sampling from a specific and limited area. Therefore, it is likely that most of the intrapopulation variation was due to different phenotypic groups in each area, associated with various environmental conditions or genetic differences.[10] Morphometric measurements were mainly limited to body structures such as fins with limited ability to determine body shape as they tended to focus along the body axis. Samplings were only from the depth along the width and mainly in the head area.[12]

This study measured 27 morphometric and 10 meristic characteristics of male and female *Hemiculter leucisculus* fish. The mean coefficients of variation of morphometric characteristics of the female (18.144) and male (17.669) fish were close to each other, indicating almost equal environmental effects on morphometric characteristics of female and male fish populations in this river. Soule and Couzin-Roudy[13] showed a negative correlation between the coefficient of variation and the heritability of morphological characteristics. In other words, environmental effects were more prominent than heritability in morphometric variation. Close means of the coefficient of variation in the two populations of male (10.714) and female (10.548) fish indicated a similar diversity of meristic characteristics in the two populations under study. However, the environmental factors did not affect meristic characteristics, and genetic factors were more influential. Winfield and Nelson[14] stated that the variation of meristic characteristics did not depend on differences in environmental conditions, but primarily under the influence of hereditary and genetic factors.

The t-test results of 27 morphometric and 10 meristic characteristics of male and female sample fish showed no significant differences in 24 morphometric and all meristic characteristics of male and female fish ($P>0.05$) and significant differences in 3 morphometric characteristics, including head depth, dorsal fin depth, and pectoral fin base length ($P\leq0.05$).

A comparison of factors extracted from multivariate analyses showed that the greater the range of variation of characteristics, the greater the number of extracted factors and eigenvalues of >1 in that group of characteristics.[15] Factor analysis of morphometric characteristics led to 10 factors with eigenvalues of >1, explaining 73.831% of the variation in characteristics. Factor analysis of meristic characteristics led to 3 factors with eigenvalues of >1, explaining 62.838% of the variation in characteristics.

Mamuris et al.,[16] stated that characteristics with a factor coefficient of >0.75 could separate populations. The first and second factors were used concerning the distributed clouds obtained by multivariate analyses because they had the highest eigenvalues, variance, and variability of characteristics.[14] The distribution of individuals based on the relationships of the first and second extracted factors shows that the two sexes under study had a good overlap in terms of morphometric and meristic characteristics. Hence, it is not possible to separate the male and female fish based on these characteristics.

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None

Conflicts of interest

The authors declare that there are no conflicts of interest.

References

1. Tudela S. Morphological variability in a Mediterranean, genetically homogeneous population of the European anchovy, *Engraulis encrasicolus*. *Fish Res*. 1999;42(3):229–243.
2. Taylor EB. A review of local adaptation in Salmonidac, with particular reference to Pacific and Atlantic salmon. Aquaculture. 1991;98(1–3):185–207.
3. Stearns SC. A natural experiment in life–history evolution: field data on the introduction of mosquitofish (*Gambusia affinis*) to Hawaii. *Evolution*. 1983;37(3):601–617.
4. Meyer A. Phenotypic plasticity and heterochrony in *Cichlasoma managuense* (Pisces, Cichlidae) and their implications for speciation in cichlid fishes. *Evolution*. 1987;41(6):1357–1369.
5. Ihssen PE, Booke HE, Casselman JM, et al. Stock identification: materials and methods. *Canad J Fish Aqua Sci*. 1981;38(12):1838–1855.
6. Allendorf FW. Conservation biology of fishes. *Conserv Biol*. 1988;2(2):145–148.
7. Bakhoum SA. Comparative study on length–weight relationship and condition factor of the genus *Oreochromis* in polluted and non–polluted parts of Lake Mariut Egypt. *Bull Nat Inst Oceanography Fish (Egypt)*. 1994;20(1):201–210.

8. Turan C. A note on the examination of morphometric differentiation among fish populations: the truss system. *Turk J Zool*. 1999;23(3):259–264.

9. Abdoli A, Naderi M. Biodiversity of fishes of the southern basin of the Caspian sea. *Abzian Sci Pub*. 2009.

10. Karakousis Y, Triantaphyllidis C, Economidis PS. Morphological variability among seven populations of brown trout, *Salmo trutta L*. in Greece. *J Fish Biol*. 1991;38(6):807–817.

11. Van Valen L. The statistics of variation. *Evol Theory*. 1978;4:33–43.

12. Purfaraj V, Karami M, Nezami Sh, et al. Study of morphological diversity *Liza aurata* (Risso ,1810) in the southern coast of the Caspian Sea. *Iran J Fish*. 2008;17:36–48.

13. Soule ME, Cuzin–Roudy J. Allomeric variation. 2. Developmental instability of extreme phenotypes. The American Naturalist. 1982;120(6):765–786.

14. Winfield IJ, Nelson JS. Cyprinid fishes: systematics, biology and exploitation. Springer Science and Business Media. 2012;3.

15. Moghadam N, Mohammadi A, Aghaie M. *Multivariate statistical methods a primer*. Pishtaz–Ealm, Tehran. 1994.

16. Mamuris Z, Apostolidis P, Panagiotaki P, et al. Morphological variation between red mullet populations in Greece. *J Fish Biol*. 1998;52(1):107–117.

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