Morphological differences among the *Cyprinion macrostomus* (Cyprinidae) populations in the Tigris River

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Received: November 2014  
Accepted: June 2015

Abstract
In this study, by examining the character of the morphometric and meristic in which *Cyprinion macrostomus* samples obtained from different locality in Tigris, morphometric character which are transformed subject to discriminant analysis and depending on grouping model to number of discriminant functions and according to importance of these totally variance, morphogical variance among populations are determined. According to the result of discriminant analysis of *Cyprinion macrostomus* individuals belonging to 5 different locality of Tigris River, it is determined that the individuals belonging to Tigris River are different from other localities both in terms of morphometric and meristic, the samples of Göksu Stream is different from other localities only in terms of meristic Devegeçidi, Kulp and Kayser Stream samples are similar in terms of morphometric and meristic.

Keywords: *Cyrinion macrostomus*, Tigris River, Discriminant analysis, Cyprinidae.
Introduction
As temperature, salinity, radiation, dissolved oxygen, water depth, current flow with environmental factors, meanwhile Dam sets which are constituted on streams, cause to differences of genotype and phenotypic by hindering fish mobility in stream basin.

There are 5 kinds of Cyprinion, these are *C. macrostomus*, *C. kais*, *C. neglectus*, *C.cypris*, *C.tenviradius* that shows a large range between Tigris and Euphrates Rivers (Banerescu and Herig Straschil, 1995). From these, *Cyprinion macrostomus* Heckel is a kind of Cyprinidae, has a huge range in Turkey, Iraq, Iran and Syrian between Tigris-Euphrates Rivers and Asi Basin. (Kelle, 1978; Kuru, 1978; Ünlü ve Oymak, 2009; Coad, 2010).

There research that are dealt with differences of morphological among populations aren’t encountered as well as characteristic of morphological and meristic related to description of this kind (Heckel, 1843; Kele, 1978; Kuru, 1978; Banarescu ve Herzig-Straschil, 1995; Ünlü, 1999; Coad, 2010). Meristic and morphometric characters are strong means for relationship of measurement among stocks (IHSSEN ve ark., 1981).

In this study, it is tried to identify the morphologic differences by examining the samples of morphlometric and meristic characters, which are obtained from different locality *C. macrostomus* in Tigris River.

Materials and Methods
The samples of *C. macrostomus* in system of Tigris River are obtained from 5 different localities, Devegeçidi Dam, Göksu small stream, Kulp Stream, Kayser Stream and Tigris River by using extension bunt and electroshocker. fish samples were brought to science lab interior 10% formaldehyde. In order to determine the features of morphological that fish samples are taken stock morphological and meristic measurement.

26 morphological variance which are about morphometric characters are measure by sensitive 0.01 mm electronic compass and in this measurement truss network method has been used (Schaefer, 1991; Turan ve ark., 2004; Tzeng, 2004; Çakmak ve Alp, 2010) (Fig. 1).

In totally 13 different variances have been used about countable meristic characters numbers of dorsal opined fin (DFRS-A) Dorsal furcated fin ray (DFRS-B), Ventral spined fin ray (VFRS-A), Ventral fructrated fin’s ray (VFRS-B), Anal opined fin ray (AFRS-A), Anal branched fin ray (AFRS-B), Pectoral fin in left spined ray (PFRSA-L), Pectoral fin in left furcated ray (PFRSB-L), Pectoral fin in right spined ray (PFRSA-R), Pectoral fin in right furcated ray (PFRSB-R), number of gill arch spine (GRS), Lateral line in left number of scale (LLS-L) and Lateral line in right number of scale (LLS-R).
In order to determine morphologic variations between *C. macrostomus* populations, all the morphometric characters are calculated to standard length (SL) and variation that could arise from Length are tried to be eliminated transformed morphometric characters are subjected to discriminant analysis and according to grouping model discriminant function numbers and morphologic variation between populations with respect to their importance of explaining total variation are determined.

In two dimensions, the place of discriminant functions are determined by taking two different discriminant functions as basis with stepwise analysis the features of classification and their influential functions are determined with the help of canonical discriminant function the limit maps of the groups in a two dimensional platform are created. Among discriminations areas the medial areas of groups (Group Centers) are arranged.

(Turan ve ark., 2004; Çakmak ve Alp 2010).

The same applications about discriminant analysis are also applied for countable meristic characters. Morphometric and meristic variations between *C. macrostomus* populations are shown on plot charts. Also morphometric differences between populations are analysed with variation analysis and F test.

**Results**

In order to investigate morphologic differences of *C. macrostomus* populations in Tigris river, 5 from Devegeçidi Dam, 5 from Göksu Stream, 20 from Kulp Stream, 27 from Kayser Stream and 30 from Tigris River in total 94 *C. macrostomus* individual are analyzed. The standard heights belonging to the samples change between 69 - 144 cm and the height difference between population a is seen statistically insignificant (*p* > 0.05).
The standard height belonging to populations and morphometric characters calculated as the percentage of standard height are given in Table 1. Of the morphometric characters FL, SL, BD, LD, OVD, PFL, AFL, PRFL, LLCFL has showed difference and this difference originates from FL/SL, SL/OVD, SL/PRFL, SL/LLCFL, BD/LD, PFL/AFL characters and Tigris, Kayser and Kulp populations.

From 13 countable meristic characters belonging to populations are 5 of them showed difference between populations (Table 2). The difference in question originates from DFRSA, DFRSB, VFRSB, GRS, L.L.S.(R) characteristics and populations of Tigris and Göksu Stream. As a result of morphometric characters which are transformed and obtained from 94 items of *C. macrostomus* individuals belonging to five different populations subjected to discriminant analysis, 4 discriminant function provide 100% of total variation. Thus function 4 is considered and the first two form 94.7% of the total variation. According to discriminant functions, 1. Function (DF1) forms 87.3% of total variation (Canonical Correlation = 0.964). 2. Function (DF2) forms 7.4% (Canonical Correlation=0.725) , 3. Function (DF3) forms 4.2% (Canonical Correlation=0.624) and 4. function (DF4) forms 1.1% (Canonical Correlation=0.369).

Canonical discriminant parameters in DF1 is -31.74, in DF2 is -6.82, DF3 is -27.40 and in DF4 is -7.53.

In discriminant analysis, in 1. function (DF1) SL/PDFL, SL/CPL, SL/HD, SL/SNL, SL/POHL, SL/BW, SL/HL, in 2. function (DF2) BD/LD, SL/BD, OVD/OHD, PFL/PEFL, SL/PPEFL, in 3.function (DF3) SL/LLCFL, SL/OVD, SL/LUCFL, SL/OHD,SL/DFL, SL/LD,PFL/DFL and UJL/LJL, and in 4.function (DF4) PFL/AFL, SL/AFL, SL/PEFL, SL/LJL, SL/PFL, HL/HV, SL/BDA, BD/BDA are significant (Table 3).

Graping chart of DF1 and DF2 scores which are obtained from morphometric characters in discriminant analysis is given in figure 2a. When grouping chart is examined it can be seen that the individuals belonging to Tigris River from a group different from other populations.

The success of discriminant analysis is 83% in terms of morphometric separation of populations. In discriminant analysis, all the Tigris samples are represented in its own group. Accordingly the representation rate of Tigris samples in its own group is 100%. While 16 samples of Kulp are represented in its own group (81.5%) the others are mixed with Kulp and Göksu samples. The representation rate of Devegeçidi samples in its own group is 40% and the rate of Göksu samples is determined as 66.7%.
As a result of countable meristic characters belonging to *C. macrostomus* individual subjected to discriminant analysis as 3 discriminant function is considered and the first two of that from 99% of total variation. First discriminant function (DF1) forms 88% of total variation (Canonical Correlation=0.987), 2. fonction forms 11% (Canonical Correlation=0.911) and 3. function forms 1% (Canonical Correlation=0.555). In discriminant analysis belonging to meristic characters, canonical parameters are calculated as 11.66 in DF1, -119.57 in DF2, and -37.66 in DF3.

In Discriminant analysis while GSR in 1. function (DF1), DFSRB in 20. Function become significant, the other meristic characters become significant in 3. function (Table 4). Grouping chart formed with scores of DF1 and DF2 belonging to meristic characters is given in shape 2b. According to grouping chart it is seen that Göksu and Tigris populations are different from other populations in terms of meristic characters.

The separation success of discriminant analysis of population is 76.6%. While all (100%) samples of Tigris take part in its own group according to the result of the separation analysis evaluation, only 2 of Kulp Stream samples take part in its own group and the others take part in Kayser Stream group.

So the rate of representation of Kulp Stream’a samples is %10, %96 individuals of Kayser Stream, 40% individuals of Devegeçidi, 100% individuals of Göksu Stream are represent in their own grasps. According to these results individuals of Göksu and Tigris in terms of meristic characters are represented in individually groups, Kayser, Devegeçidi and Kulp individuals an form only a single mixed group (Shape 2b).

Consequently, according to the result of discriminant analysis of *C. macrostomus* individuals belonging to five different localities of Tigris River, the individuals belonging to Tigris River are determined to be different from other localities both is terms of morphometric and meristic, samples of Göksu Stream are only different from other localities in terms of meristic, samples of Devegeçidi, Kulp and Kayser are determined to be similar in terms of morphometric and meristic.
### Table 1: Morphometric features of different *Cyprinion macrostomus* populations in Tigris River.

| Morphometric Character | Devegeçidi Dam (n=5) | Göksu Stream (n=12) | Kulp Stream (n=20) | Kayser Stream (n=27) | Tigris River (n=30) |
|------------------------|-----------------------|----------------------|---------------------|-----------------------|---------------------|
| SL                     | 1.11                  | 1.17                 | 1.15                | 1.16                  | 1.28                |
| SNL                    | 13.49                 | 12.19                | 12.09               | 12.54                 | 11.27               |
| OHD                    | 20.49                 | 16.82                | 19.88               | 19.06                 | 20.07               |
| OVD                    | 21.10                 | 17.24                | 20.81               | 19.24                 | 20.11               |
| UJL                    | 14.03                 | 12.58                | 14.73               | 14.99                 | 14.1                |
| LJL                    | 8.54                  | 7.63                 | 7.06                | 7.97                  | 8.06                |
| HL                     | 5.03                  | 4.4                  | 4.5                 | 4.73                  | 4.35                |
| HD                     | 6.85                  | 0.74                 | 6.3                 | 6.5                   | 6.2                 |
| POHDL                  | 10.8                  | 1.03                 | 9.6                 | 9.98                  | 9.34                |
| PFL                    | 5.75                  | 0.43                 | 5.33                | 5.48                  | 5.15                |
| BD                     | 3.75                  | 0.299                | 3.97                | 3.98                  | 3.35                |
| BW                     | 5.79                  | 0.63                 | 6.18                | 5.82                  | 4.94                |
| DFL                    | 5.72                  | 0.78                 | 5.29                | 5.23                  | 5.26                |
| PDFL                   | 2.41                  | 0.199                | 2.23                | 2.24                  | 1.99                |
| PFL                    | 6.52                  | 0.724                | 5.61                | 5.75                  | 5.2                 |
| PPEFL                  | 2.22                  | 0.26                 | 2.15                | 2.74                  | 1.9                 |
| DPA                    | 4.78                  | 0.45                 | 5.01                | 4.9                   | 4.2                 |
| BDA                    | 6.25                  | 0.478                | 6.18                | 8.35                  | 5.16                |
| AFL                    | 7.12                  | 1.31                 | 6.56                | 6.02                  | 5.068               |
| CPL                    | 7.13                  | 0.64                 | 6.53                | 6.6                   | 5.75                |
| LD                     | 11.35                 | 0.739                | 10.49               | 10.6                  | 9.26                |
| LUCFL                  | 4.34                  | 0.527                | 3.7                 | 3.6                   | 3.48                |
| LMCFR                  | 8.89                  | 1.74                 | 8.4                 | 8.57                  | 8.27                |
| LLCLFL                 | 13.4                  | 20.49                | 3.78                | 3.77                  | 3.63                |

### Table 2: Meristic features of different *Cyprinion macrostomus* populations in Tigris River.

| Meristic Character | Devegeçidi Dam (n=5) | Göksu Stream (n=12) | Kulp Stream (n=20) | Kayser Stream (n=27) | Tigris River (n=30) |
|-------------------|-----------------------|----------------------|---------------------|-----------------------|---------------------|
| DFSR-A            | 3.60±0.55             | 4.00±0.00            | 4.00±0.04           | 3.96±0.19             | 3.33±0.48           |
| (min-mak)         | (min-mak)             | (min-mak)            | (min-mak)           | (min-mak)             | (min-mak)           |
| DFSR-B            | 14.80±0.83            | 14.4±0.00            | 14.9±0.00           | 15.00±0.00            | 14.5±0.51           |
| (min-mak)         | (min-mak)             | (min-mak)            | (min-mak)           | (min-mak)             | (min-mak)           |
| VFRS-A            | 1.00±0.00             | 1.00±0.00            | 1.00±0.00           | 1.00±0.00             | 1.00±0.00           |
| (min-mak)         | (min-mak)             | (min-mak)            | (min-mak)           | (min-mak)             | (min-mak)           |
| VFRS-B            | 8.20±0.44             | 8.00±0.00            | 8.00±0.366          | 8.00±0.00             | 8.00±0.00           |
| (min-mak)         | (min-mak)             | (min-mak)            | (min-mak)           | (min-mak)             | (min-mak)           |
| AFRS-A            | 3.00±0.00             | 3.00±0.00            | 2.85±0.00           | 3.00±0.00             | 3.00±0.00           |
| (min-mak)         | (min-mak)             | (min-mak)            | (min-mak)           | (min-mak)             | (min-mak)           |
| AFRS-B            | 7.20±0.44             | 7.00±0.00            | 7.00±0.00           | 7.00±0.00             | 7.00±0.00           |
| (min-mak)         | (min-mak)             | (min-mak)            | (min-mak)           | (min-mak)             | (min-mak)           |
| PFRSA-L           | 1.00±0.00             | 1.00±0.00            | 1.00±0.00           | 1.00±0.00             | 1.00±0.00           |
| (min-mak)         | (min-mak)             | (min-mak)            | (min-mak)           | (min-mak)             | (min-mak)           |
| PFRSB-L           | 13.00±0.00            | 13.00±0.00           | 13.00±0.00          | 13.00±0.00            | 13.00±0.00          |
| (min-mak)         | (min-mak)             | (min-mak)            | (min-mak)           | (min-mak)             | (min-mak)           |
| PFRSA-R           | 1.00±0.00             | 1.00±0.00            | 1.00±0.00           | 1.00±0.00             | 1.00±0.00           |
| (min-mak)         | (min-mak)             | (min-mak)            | (min-mak)           | (min-mak)             | (min-mak)           |
| PFRSB-R           | 13.00±0.00            | 13.00±0.00           | 13.00±0.77          | 13.00±0.00            | 13.00±1.5           |
| (min-mak)         | (min-mak)             | (min-mak)            | (min-mak)           | (min-mak)             | (min-mak)           |
| GRS                | 32.60±2.61            | 40.42±1.24           | 30.20±1.07          | 30.11±0.8             | 26.27±2.86          |
| (min-mak)         | (min-mak)             | (min-mak)            | (min-mak)           | (min-mak)             | (min-mak)           |
| LLS-L              | 43.00±2.83            | 40.17±1.03           | 40.90±0.99          | 40.37±1.27            | 41.53±4.15          |
| (min-mak)         | (min-mak)             | (min-mak)            | (min-mak)           | (min-mak)             | (min-mak)           |
| LLS-R              | 43.20±2.17            | 30.08±1.31           | 41.15±1.037         | 41.19±1.07            | 41.73±4.35          |
| (min-mak)         | (min-mak)             | (min-mak)            | (min-mak)           | (min-mak)             | (min-mak)           |
Table 3: Discriminant functions (DF1, DF2, DF3) formed by using morphometric characters in discriminant analysis.

| Morphometric parameter | DF1  | DF2  | DF3  | DF4  |
|------------------------|------|------|------|------|
| SL/PDFL                | -0.345 | -0.201 | 0.115 | -0.218 |
| SL/CPL                 | -0.333 | 0.220 | 0.015 | 0.020 |
| SL/DPA                 | -0.299 | 0.172 | -0.085 | 0.165 |
| SL/HD                  | -0.298 | -0.052 | 0.228 | -0.038 |
| SL/SNL                 | -0.281 | 0.030 | 0.002 | -0.007 |
| SL/POHL                | -0.186 | -0.023 | 0.180 | -0.150 |
| SL/BW                  | -0.183 | 0.054 | 0.001 | -0.076 |
| SL/HL                  | -0.181 | -0.086 | 0.123 | -0.171 |
| BD/LD                  | 0.016 | 0.523 | 0.302 | 0.351 |
| SL/BD                  | -0.145 | -0.473 | -0.126 | -0.413 |
| OVD/OHD                | 0.089 | 0.388 | -0.116 | 0.045 |
| PFL/PEFL               | -0.097 | 0.344 | 0.250 | -0.176 |
| SL/LMCFR               | 0.036 | -0.159 | 0.092 | -0.085 |
| SL/UUL                 | -0.076 | -0.151 | -0.127 | -0.039 |
| SL/PPEFL               | -0.014 | -0.039 | 0.030 | 0.037 |
| SL/LLCFL               | 0.037 | 0.160 | 0.544 | -0.442 |
| LUCFL/LLCFL            | -0.025 | 0.160 | 0.527 | -0.436 |
| SL/OVD                 | 0.037 | -0.454 | 0.509 | -0.416 |
| SL/LUCFL               | -0.193 | 0.053 | 0.471 | -0.203 |
| SL/OHD                 | 0.102 | -0.070 | 0.375 | -0.343 |
| SL/DFL                 | -0.161 | -0.200 | 0.292 | -0.245 |
| SL/LD                  | -0.196 | 0.033 | 0.255 | -0.111 |
| PFL/DFL                | -0.068 | -0.140 | 0.192 | 0.036 |
| UJL/LJL                | 0.036 | 0.042 | 0.131 | -0.016 |
| PFL/AFL                | -0.253 | -0.142 | 0.395 | 0.836 |
| SL/AFL                 | -0.321 | -0.176 | 0.420 | 0.578 |
| SL/PEFL                | -0.198 | 0.287 | 0.340 | -0.422 |
| SL/LJL                 | -0.193 | -0.242 | 0.274 | -0.422 |
| SL/PFL                 | -0.116 | -0.077 | 0.105 | -0.334 |
| HL/HD                  | -0.052 | 0.053 | 0.004 | 0.160 |
| SL/BDA                 | -0.033 | -0.044 | -0.098 | -0.152 |
| BD/BDA                 | -0.024 | -0.008 | -0.089 | -0.122 |

Table 4: Discriminant functions (DF1, DF2, and DF3) formed by using meristic characters in discriminant analysis.

| Meristic Character | DF1  | DF2  | DF3  |
|-------------------|------|------|------|
| GRS               | -0.683 | 0.370 | 0.376 |
| LLS-R             | 0.464 | 0.305 | 0.733 |
| VFRSB             | -0.002 | 0.057 | 0.704 |
| AFRSB             | -0.002 | 0.057 | 0.704 |
| L.L.S.( L)ª       | 0.054 | 0.121 | 0.582 |
| DFSRB             | 0.094 | 0.310 | -0.149 |
| DFSRA             | -0.081 | 0.348 | -0.508 |
| AFRSAª            | 0.037 | 0.071 | -0.108 |
1. TL: Total Length  2. FL: Fork Length,
3. SL: Standard Length  4. SNL: Snout Length
5. OHD: Horizontal Ocular Diam  6. OVD: Vertical Ocular Diam
7. USL: Upper Lip Length  8. LIL: Lower lip Length
9. HL: Head Length  10. HD: Head Height
11. POHL: Post Ocular Head Length  12. PFL: Pectoral Fin Length
13. BD: Body Height  14. BW: Body Width
15. DFL: Dorsal Fin Length  16. PDFL: Predorsal Length
17. Pelvic Fin Length  18. PPEFL: Prepelvik Length
19. DPA: Distance Between Pelvik and Anal Fin
20. BDA: Body Height in Anal Level
21. Anal Fin Length  22. CPL: Caudal Pedunculus Length
23. LD: Body Height in Caudal Pudunculus Area
24. LUCFL: Upper Lab Length of Caudal Fin
25. LMCFR: Caudal Fin’s Fork’s Length
26. LLCFL: Length of Lower Lab of Caudal Fin.

Figure 1-a: Morphometric measurement performed upon *Cyprinion macrostomus*.

Figure 1-b: Metristic characters performed upon *Cyprinion macrostomus*.
DFRS(A): Dorsal Ray Score (spine), DFRS(A): Dorsal Ray Score (branched), VFRS(A): Ventral Ray Score (spine), VFRS(B): Ventral Ray Score (branched), AFRS(A): Anal Ray Score (Spine), AFRS(B): Anal Ray Score (Branched), PFRSA(L): Pectoral Ray Score (Left part branched), PFRSA(R): Pectoral Ray Score (Right Part Spine), PFRSB(R): Pectoral Ray Score (Right Part Branched), GRS: Spine Score of Gill Arch, L.L.S.(L): Lateral Line Score (Left Part), L.L.S.(R): Lateral Line Score (Right part).

Figure 2: The difference between Granping charts of function 1 and function 2 found as a result of discriminant analysis and populations.
a) Discriminant analysis results belonging to morphometric characters  
b) Discriminant analysis results belonging to meristic scores.

*Figure 1-a*
In the analysis which is performed according to the morphometric features of 94 *C. macrostomus* (Heckel, 1843) which are brought from 5 different regions the separation success rate of localities group in term of meristic features is 83%.

In the result of evaluation for separation analysis: Of the 30 all samples brought from Tigris the 30 stayed its own group. Samples brought from Tigris in terms of studied characters are 100% probably P=1. While of 20 samples brought from Kulp 16 of them stay in its own group 4 of them passed to Kayser group. Samples brought from Kulp in terms of studied characters get involved in its own group as percentage is 80%, as possibility P=0,8.

Of 27 samples brought from Kayser 22 of them stayed in its own group and 2 of them passed to Göksu group. Samples brought from Kayser in terms of studied characters get involved in its own group as percentage is 81,5% and as possibility P=0,85.

Of the 5 samples brought from Devegeçidi 2 of them stayed in own group and 1 of them passed to Göksu group. Samples brought from Devegeçidi in terms of studied characters get involved in its own group as percentage is 40% and as possibility P=0,40.

Of 12 samples brought from Göksu 8 of them stayed in its own group and them pased to Kayser and 1 of them passed to Tigris group. Samples brought from Göksu in terms of studied characters get involved in own group as percentage 66,7% and as possibility p=0.667.

*Figure 1-b*
In the analysis which is performed according to the meristic features of *C. macrostomus* (Heckel, 1843) samples brought from 5 different regions the success rate is 76,6% in terms of separating locality groups meristically.

In the result of separation analysis; of the 30 samples brought from Tigris the all 30 stayed in its own group, samples brought from Tigris in terms of studied characters are 100% probably P=1. While of 20 samples brought from Kulp Stream 20 of them stay in its own group the rest 18 stayed in Kayser group. Samples brought from Kulp in terms of studied characters get involved in its own group as percentage is10% probably P=0.1.

Of 27 samples brought from Kayser 26 of them stayed in its own group the remaining 1 passed to Tigris group. Samples brought from Kayser Stream in terms of studied characters get involved in its own group as percentage is96,3% probably P=0.963.

Of the five samples brought from Devegeçidi 2 of them stayed in its own
group and 1 passed to Kayser and 1 passed to Kulp group. Samples brought from Devegeçidi in terms of studied characters get involved in its own group is 40% probably P=0.4.

Of the 12 samples brought from Göksu 12 of them stayed in its own group samples brought from Göksu in terms of studied characters get involved in its own group is 100% probably P=1.

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