Turkish Journal of Fisheries and Aquatic Sciences 6: 17-21 (2006)

Preliminary Results on Morphometry of Barbel (*Barbus tauricus* Kessler, 1877) in the Streams of Rize and Artvin Provinces (Turkey)

Bülent Verep[1,]*, Davut Turan[1], Vladimír Kováč[2]
[1] Karadeniz Technical University, Rize Faculty of Fisheries and Aquatic Sciences, 53100, Rize, Turkey.
[2] Comenius University, Faculty of Natural Sciences, Department of Ecology, Mlynská dolina B2, Bratislava, Slovakia.

* Corresponding Author: Tel.: +90. 464 223 33 85, Fax: +90. 464 223 41 18;
E-mail: verep@ktu.edu.tr

Received 17 June 2005
Accepted 07 March 2006

Abstract

Growth variability in 10 metric characters of *Barbus tauricus* (Kessler, 1877), from nine tributaries of the streams in Rize and Artvin Provinces (Turkey) was examined. The SL of 238 barbel specimens studied ranged from 54 to 198 mm, TL ranged from 62 to 226 mm. The sub-populations from all locations appeared to be relatively uniform in all of the characters examined. Six metric characters demonstrated isometric growth, i.e. they were best described by simple linear regressions and one character (eye diameter) was the best described by split linear regression, being isometric with an abrupt change in its growth rate relative to SL. The authors suggest that further morphological investigation of the species is required.

Keywords: Morphometry, Ecomorphology, *Barbus tauricus*, Regression analysis, Sub-populations, Turkey

Introduction

Comparing anatomical features of organisms has been a central element of biology for centuries. Both, taxonomic classification of organisms, and understanding the diversity of biological life, were historically based on descriptions of morphological forms (Dean *et al.*, 2003). In fish, morphometric characters represent one of the major keys for determining their systematics, growth variability, ontogenetic trajectories (Kováč *et al.*, 1999) and/or various population parameters.

In the literature, studies about ecomorphology of fish are new topics and they concentrate on variability of growth and morphometric characters and ecological properties of fish populations. Kovac *et al.* (1999) made studies on stone loach, *Barbatula barbatula,* and examined it in terms of growth variability and breakpoints in development of metric characters. In another study of Kovac *et al.* (2002), comparative morphology of threespine *Gasteriostus aculetus* and ninespine *Pungitius pungitius* stickleback was studied. And Copp *et al.* (2002) worked on growth, morphology and life history traits of *Lepomis gibbosus*. Because of the few studies on morphometric differences between sub-populations of a species in literature, these were studied in this work.

The patterns of relative growth were determined using the triple regression analysis of the raw data for the metric characters (SL, FL and TL excepted) plotted against SL. Basically, there were three possible patterns in growth variability of the metric characters:

1- growth proportional to that of SL throughout the ontogeny (isometric growth);

2- growth proportionally faster or slower than SL (positive or negative allometric growth); and

3- growth proportional (isometrical) up to a certain SL followed by a shift to a different proportional rate (either faster or slower).

Thus, isometric growth is linear, whereas gradual allometry could be best explained by a quadratic regression, either concave upwards (character grows proportionally faster than SL) or concave downwards (character grows proportionally slower than SL). Shifts in isometric growth, which separate two intervals of isometric growth, are revealed by a split, or estimated break point, between two linear regressions (Nickerson *et al.*, 1989).

The aim of the present study is

1- to provide basic data on external morphology (selected morphometric characters) of *Barbus tauricus* from nine tributaries of the rivers in Rize and Artvin Province;

2- to determine whether there are significant morphometric differences between sub-populations from the streams of the catchment area examined (all locations and localities belong to the same climatologic region); and

3- to analyze growth variability of the characters studied.

Material and Methods

The Barbel (*Barbus tauricus* Kessler, 1877) has a low framed and laterally compressed body covered with middle-sized cyloid scales, lower mouth and two pairs of barbells (Figure 1). It inhabits mainly streams, though it also occurs in lakes. It prefers well-oxygenated sections with gravel bottom and high current velocity. The barbel is not an economically important species, because of its small size, but it is consumed in rural areas in the streams in Rize Province catchment areas (Turkey) (Turan, 2003).

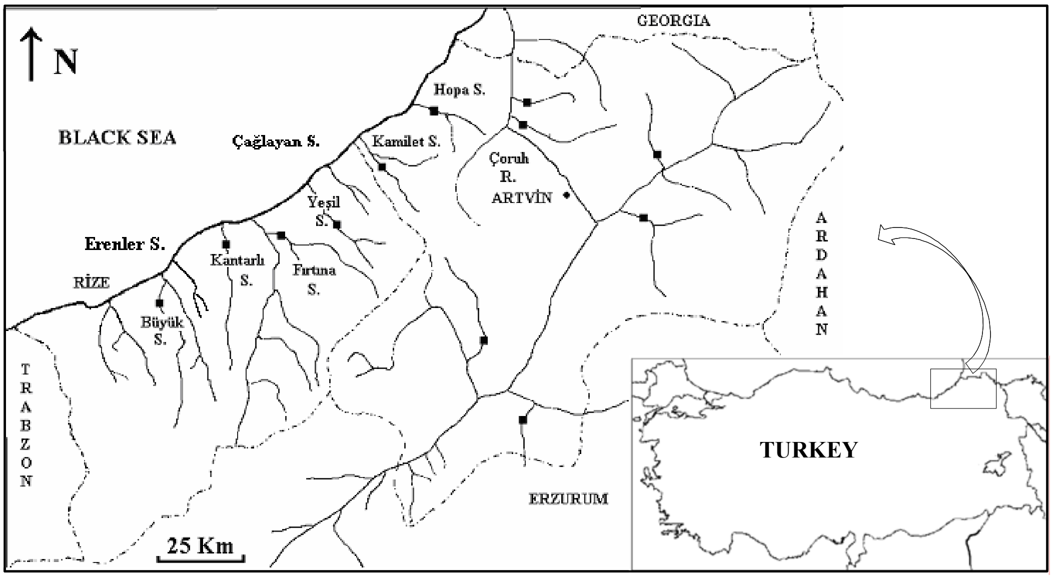

Figure 1. Map of the sampling sites at the catchment areas of the streams in Rize and Artvin Provinces. (the river enters Black Sea).

The distribution area of the species extends from the Black Sea to the Aegean Sea streams (Banarescu and Bogutskaya, 1999).

Specimens of *Barbus tauricus* from nine tributaries of the streams in Rize and Artvin Provinces, Turkey (Figure 1), were collected by electro-fishing between May and September 2000. A total of 238 specimens from the following nine locations were examined: Kale (n = 43), Büyükçay (n = 40), Kantarlı (n = 29), Fırtına (n = 26), Erenler (n = 20), Yeşil (n = 10), Çağlayan (n = 11), Kamilet (n = 19) and Hopa (n = 40). Sampling sites at the locations studied were chosen randomly. In the laboratory, 10 metric characters, including total length (TL), forked length (FL) and standard length (SL; Table 1), were measured to the nearest 0.01 mm.

In this study for prospective inter-population comparisons, all metric characters except SL, FL and TL were expressed in percent SL and were evaluated using variation analysis (Snedecor, 1946). In the between-stream comparisons, the coefficient of difference (C_{dif}) was used in each character:

$$C_{dif} = \frac{x_2 - x_1}{SD_1 + SD_2}$$

where x_2 and x_1 are the arithmetic means, and SD_1 and SD_2 are the standard deviations of the metric characters at the sites compared. Real difference in a metric character between 90 % of the population from two given sites existed when the absolute value was $C_{dif} > 1.28$ (Mayr and Linsley, 1953).

Each relationship between a character and SL of barbel, was tested for linearity (isometry), gradual allometry and split linearity as described in Kováč *et al.* (1999). Our null hypothesis was that relative growth in each character was isometric, and therefore was best described by a simple linear regression. The first alternative hypothesis was that relative growth in each character was gradual allometric, and was best described by a quadratic equation. The second alternative hypothesis was that relative growth in each character occurred in two different isometric intervals and was best described by a split linear regression. We fitted simple linear, quadratic and split linear regression models to plots of the dependent variables against SL, and tested the quadratic and split linear models for significant improvements in fit over the simple linear model using *F*-tests as described by Sokal and Rholf (1981) and Kováč *et al.* (1999). The second alternative hypothesis was only accepted if the split-linear fit was significantly better than both the simple linear and quadratic fits.

Results

The SL and TL of 238 barbel specimens from Rize region ranged from 54 to 198 mm and from 62 to 226 mm, respectively. Concerning proportional values between each character and SL, eye diameter was the most variable, whereas the least variability was found in pre-dorsal distance (Table 1).

The sub-populations from Kale, Büyükçay, Kantarlı, Fırtına and Hopa appeared to be relatively uniform in all of the characters examined (Table 2). Although the remaining four sub-populations were not included in this analysis due to insufficient number of specimens, they do not seem to differ from each other, either (Figure 2).

Discussion and Conclusion

Six characters were examined in barbel demonstrated isometric growth, i.e. they were best

Table 1. Mean, standard deviation (SD), coefficient of variance (C.var) and number of specimens (n) for metric characters of *Barbus tauricus* from tributaries of the Rivers in Rize and Artvin Provinces (Turkey)

	Character	mean	SE	SD	Min	Max	C.var.	n
	in mm							
	Total length	123.29	0.128	30.57	62.00	226.00	24.79	238
	Forked length	114.93	0.120	28.48	62.00	214.00	24.78	238
	Standard length	106.29	0.112	26.59	54.00	198.00	25.01	238
	in % of Standard length							
1	Head length	25.28	0.006	1.37	19.72	30.51	5.40	238
2	Preorbital distance	10.44	0.004	0.92	7.90	14.23	8.85	238
3	Eye diameter	4.46	0.002	0.53	3.21	6.21	12.00	238
4	Interorbital dist.	7.35	0.002	0.53	6.01	9.20	7.20	238
5	Body depth	21.98	0.006	1.54	17.13	27.37	6.99	238
6	Predorsal distance	51.60	0.010	2.39	39.98	61.97	4.63	238
7	Postdorsal distance	40.13	0.009	2.10	34.62	46.23	5.24	238

Table 2. Absolute values for the coefficients of difference (C_{dif}) between sub-populations of *Barbus tauricus* from the locations (tributaries of the Rivers in Rize and Artvin Provinces) studied. Kl – Kale, Bü – Büyükçay, Kn – Kantarli, Fi – Fırtına, Ho – Hopa. No significant differences in metric characters between the respective sub-populations were found

No	Character	Locations compared									
		Kl/Bü	Kl/Kn	Kl/Fi	Kl/Ho	Bü/Kn	Bü/Fi	Bü/Ho	Kn/Fi	Kn/Ho	Fi/Ho
1	Head length	0.29	0.18	0.06	0.37	0.04	0.21	0.15	0.13	0.15	0.30
2	Preorbital dist.	0.52	0.08	0.23	0.32	0.41	0.31	0.30	0.14	0.21	0.06
3	Eye diameter	0.25	0.20	0.25	0.25	0.41	0.52	0.02	0.00	0.38	0.48
4	Interorbital dist.	0.17	0.29	0.08	0.10	0.57	0.26	0.05	0.19	0.41	0.18
5	Body depth	0.25	0.22	0.30	0.02	0.37	0.40	0.24	0.11	0.25	0.33
6	Predorsal dist.	0.02	0.10	0.04	0.16	0.11	0.03	0.24	0.08	0.26	0.25
7	Postdorsal dist.	0.67	0.06	0.03	0.11	0.64	0.68	1.11	0.09	0.20	0.07

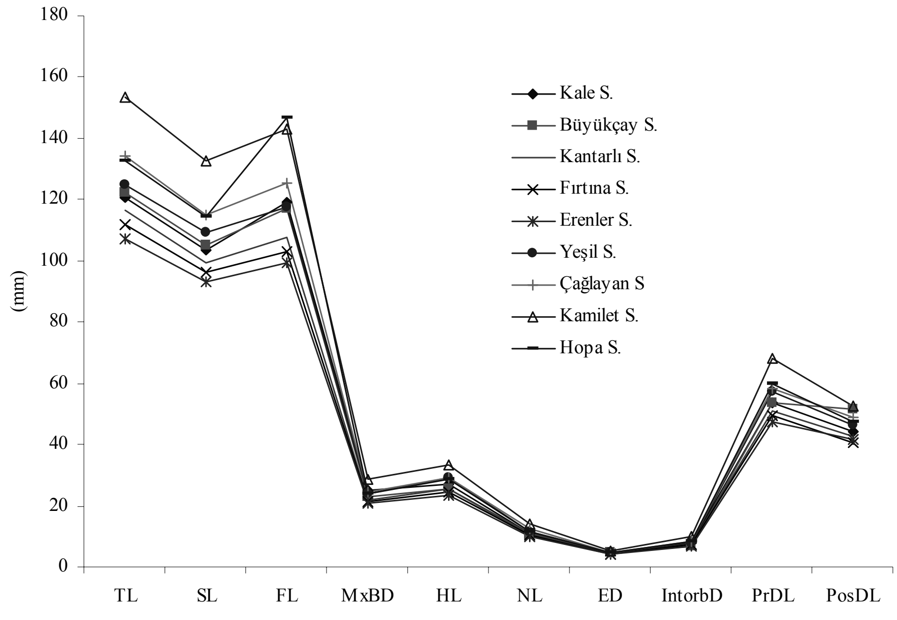

Figure 2. Mean of the morphometric data of *Barbus tauricus* from each of the locations studied.

described by simple linear regressions; and one character (eye diameter) was best described by split linear regression, being isometric with an abrupt change in its growth rate relative to SL (F-test, Table 3). This means that in *Barbus tauricus* such characters as body depth, head length, pre-orbital distance, interorbital distance, pre-dorsal distance and post-dorsal distance keep their proportions relative to the size of fish, and thus are recommended to be used in taxonomical and/or comparative studies. On the other hand, the eye diameter appears to depend strongly on the size of fish (SL), though it grows isometrically up to 100 – 114 mm SL (this interval included the breakpoint and its standard error, (Table 3) when its proportional size reduced considerably, and then grew isometrically again (Figure 3). Therefore, eye diameter should be taken with caution in taxonomical and comparative studies. As a result, the question remains, whether the size-related variability in eye diameter is important from an ontogenetic and/or eco-morphological point of view. To answer this question, further investigation that is focusing on more morphometric characters is required.

Acknowledgements

Participation of VK at this research was supported by the Slovak Scientific Grant Agency VEGA, Project No 1/9112/02.

Table 3. Statistics for linear (L), quadratic (Q) and split linear (S) regressions for metric characters of *Barbus tauricus* from tributaries of the River Rize, Turkey, with probabilities, standard error and number

Character	R^2 for L	R^2 for Q	F Q/L	P	R^2 for S	F S/Q	P	F S/L	P	fit	Break point	SE
Head length	0.9546	0.9548	1.04	NS	0.9547	-0.52	NS	0.26	NS	L	-	-
Preorbital distance	0.9142	0.9142	0.00	NS	0.9150	2.21	NS	1.11	NS	L	-	-
Eye diameter	0.7994	0.8047	6.35	<0.05	0.8085	4.66	<0.05	5.58	<0.05	S	107.0	7.7
Interorbital dist.	0.9192	0.9194	0.58	NS	0.9200	1.76	NS	1.18	NS	L	-	-
Body depth	0.9196	0.9199	0.88	NS	0.9202	0.88	NS	0.88	NS	L	-	-
Predorsal distance	0.9673	0.9674	0.72	NS	0.9675	0.72	NS	0.72	NS	L	-	-
Postdorsal distance	0.9637	0.9642	3.27	NS	0.9641	-0.65	NS	1.31	NS	L	-	-

n = 238
NS = not significant

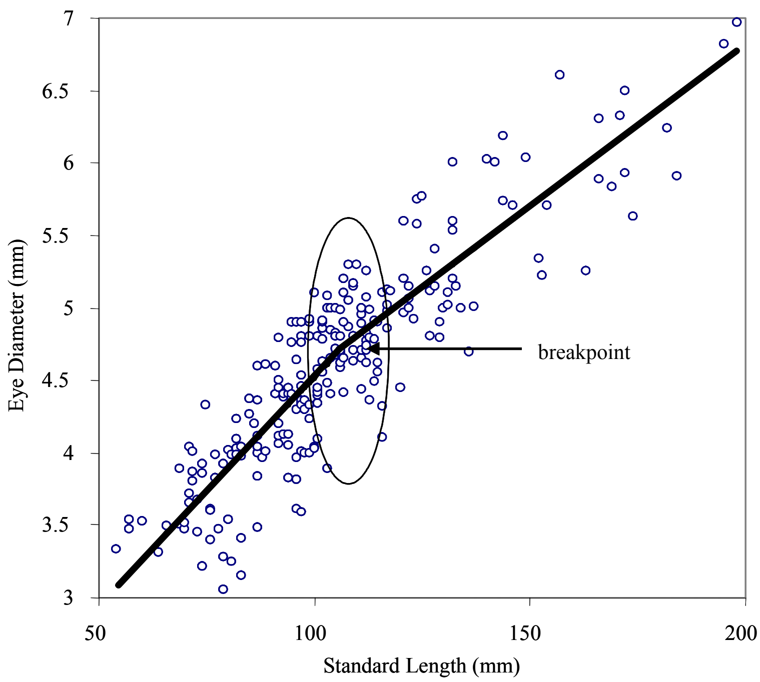

Figure 3. Scattergram of eye diameter plotted against SL (both in mm) and the model of split linear regression for the raw data, which appeared to provide better fit than that of linear and/or quadratic regressions (see Table 4). The breakpoint between two intervals of otherwise isometric growth occurs at 107 mm SL, though the interval of change designated by standard error ranges from 100 to 114 mm SL.

References

Banarescu, P.M. and Bogutskaya, N.G. 2003. The Freshwater Fishes of Europe: Cyprinidae 2. Part II: Barbus. Vol. 5/II, AULA-Verlag GmbH Wiebelsheim, 454 pp.

Copp, G.H., Fox, M.G. and Kováč, V. 2002. Growth, morphology and life history traits of a cool-water European population of pumpkinseed *Lepomis gibbosus*. Arch. Hydrobiol., 155(4): 585-614.

Dean, C.A., Rholf, F.J. and Dennis, E.S. 2004. Geometric morphometrics: Ten years of progress following the revolution. Ital. J. Zool., 71: 5-16.

Kováč, V. and Copp, G.H. 1999. Morphometry of the stone loach *Barbatula barbatula* (L.). Do metric characters reflect the species' life history thresholds? Environ. Biol. Fish., 56: 105-115.

Kováč, V., Copp, G.H., Dimart, Y. and Uzikova, M. 2002. Comparative morphology of threespine *Gasterosteus aculeatus* and ninespine *Pungitius pungitius* sticklebacks in lowland streams of shoutheastern England. Folia Zool., 51(4): 319-336.

Mayr, E., Linsley, E.G. and Usinger, R.L. 1953. Methods and Principles of Systematic Zoology. McGraw-Hill, New York, 328 pp.

Nickerson, D.M., Facey, D.E. and Grossman, G.D. 1989. Estimating physiological thresholds using two-phase segmented regression. Physiological. Zoology, 62: 866-887.

Snedecor, G.W. 1946. Statistical Methods. 4th edition, Iowa State College Press, Iowa, 75 pp.

Sokal, R.R. and Rholf, F.J. 1981. Biometry. 2nd edition, W.H. Freeman, San Francisco, 859 pp.

Turan, D. 2003. Investigation of Freshwater Fishes of Rize and Artvin Province in terms of Systematics and Ecology (In Turkish). PhD Thesis. İzmir: University of Aegean.