



Relationships Between Opercle Dimensions and Total Length of European Perch (*Perca fluviatilis* L., 1758) Inhabiting Lake Ladik (Samsun, Turkey)

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ABSTRACT

In this study, the relationships between total length and opercle dimensions (length and height) of European perch inhabiting Lake Ladik were examined. Sampling was carried out between January and February 2010. A total of 110 individuals were sampled and total length ranged from 11.6 to 24.7 cm. Opercles were extracted for all fish caught. Opercle length (*OL*) and height (*OH*) were measured discriminating the right and left of each pair of opercle. *OL* and *OH* ranged from 10.04 to 24.32 mm and 9.23 to 20.67 mm, respectively. Total length-opercle length and total length-opercle height relationships were calculated separately for right and left opercle. The results of statistical estimates indicated that the linear model had higher regression coefficient than the power model for both relationships. The regression coefficients of the total length-opercle length and total length-opercle height regression equations were 0.951 ($p<0.001$), 0.936 ($p<0.001$), respectively. When right and left opercles were compared, we found that there was significant distinctness in terms of opercle length ($p<0.001$) but there was no significant difference in terms of opercle height ($p>0.05$).

Keywords: Opercle, Biometry, Total Length, Perch, *Perca fluviatilis*

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Ladik Gölü (Samsun, Türkiye)'nde Yaşayan Tatlısu Levreği (*Perca fluviatilis* L., 1758)'nin Operkül Boyutları ile Balığın Total Boyu Arasındaki İlişkiler

Öz: Bu çalışmada Ladik Gölü'nde yaşayan tatlısu levreğinin total boyu ile operkül boyutları (boy ve yükseklik) arasındaki ilişkiler incelenmiştir. Örnekleme Ocak ve Şubat 2010 tarihleri arasında gerçekleştirilmiştir. Toplamda 110 birey örneklenmiştir ve total boyları 11,6 ile 24,7 cm arasında değişmiştir. Tüm yakalanan balıklardan sağ ve sol operküller alınmıştır. Her operkül çiftinin sağ ve sol ayrımı yapılarak operkül boyları ve operkül yükseklikleri ölçülmüştür. Operkül boy (*OB*) ve yüksekliği (*OY*), sırasıyla 10,04-24,32 mm ve 9,23-20,67 mm arasında değişmiştir. Total boy-operkül boyu ve total boy-operkül yüksekliği arasındaki ilişkiler sağ ve sol operküller için ayrı ayrı hesaplanmıştır. İstatistiksel analizler sonucunda hem total boy-operkül boyu hem de total boy-operkül yüksekliği arasında doğrusal model üssel modelden daha yüksek regresyon katsayısına sahiptir, regresyon katsayıları da bu ilişkiler için sırasıyla 0,951 ($p<0,001$), 0,936 ($p<0,001$)'dir. Sağ ve sol operküller birbirleriyle karşılaştırıldığında operkül boyu bakımından aralarında istatistiksel olarak önemli farklılık mevcuttur ($p<0,001$) fakat operkül yüksekliği bakımından herhangi bir farklılık yoktur ($p>0,05$).

Anahtar kelimeler: Operkül, Biyometri, Total Boy, Tatlısu Levreği, *Perca fluviatilis*

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Introduction

The European perch *Perca fluviatilis* (L., 1758) is the most common and widely distributed member of the Percidae, and is important both commercially and for sport fishing. It is widespread throughout Europe and Asia, in addition to its native distribution,

it has been successfully introduced in other parts of the world, mainly South Africa, Australia and New Zealand (Thorpe 1977). This species is cultivated in some countries (Beğburs 2001). Perch is one of the economic freshwater fishes inhabiting Lake Ladik. It is consumed by

Esox lucius and *P. fluviatilis* in Lake Ladik (Yazicioglu 2014).

The opercle is typically well preserved, its variation can be of taxonomic relevance (Hilton 2003; López-Arbarello 2012; Marceniuk et al. 2012), and several works have used the bone as a model to examine the relation between morphological evolution and development (Kimmel et al. 2005). Variability in opercle shape among freshwater populations was also found to be associated with the habitat (Arif et al. 2009).

The ability to estimate the original size of an ingested prey item is an important step in understanding the community and population structure of piscivorous predators (Scharf et al. 1998). More specifically, knowledge of original prey size is essential for deriving important biological information, such as predator consumption rates, biomass of the prey consumed, and selectivity of a predator towards a specific size class of prey (Hansel et al. 1988; Scharf et al. 1997; Radke et al. 2000). Stomach-content analyses are the most common methods for examining the diets of piscivorous fish, but the prey items found are often thoroughly digested and sometimes unidentifiable. As a result, obtaining a direct measurement of prey items is frequently impossible. Because of the problems of reconstructing original prey size directly from prey remains, numerous methods involving correlations between measurements of specific morphological features of the prey and prey size (length) have been devised (Wood 2005).

In this study we aimed to determine the relationships between total length and opercle dimensions (length and height) of European perch (*Perca fluviatilis* L., 1758) inhabiting Lake Ladik. In particular, total length can be estimated using opercle dimensions of ingested perch individuals by top predators (e.g. pike).

Materials and Methods

Lake Ladik (35°40'-36°05' E - 40°50'-41°00' N) is one of the few lakes containing floating islands in the world. The lake has a length of 5 km, width of 2 km, depth of 2.5-6 m and altitude of 867 m (Anonymous 2007). Economically important fish species are *E. lucius*, *P. fluviatilis* and *Abramis brama*.

Sampling was carried out between January and February 2010. A total of 110 individuals were obtained using gillnets with mesh sizes (bar length) of 20, 25, 30, 35 and 40 mm. Total length (TL) (nearest ± 0.1 cm) was measured and opercles were extracted from all the fish caught. Opercle length (OL) and height (OH) were measured discriminating

the right and left of each opercle, using a digital caliper (nearest ± 0.01 mm) (Figure 1).

Power and linear models were applied to the relationships between opercle length, height and total length, consequently the model which had the highest regression coefficient was preferred. We also tested whether there were any differences between the right and left opercle dimensions with the Wilcoxon test which is a non-parametric t test. Because data were not normally distributed, so we tested with a non-parametric of the paired t test. Descriptive statistics of total length, opercle length and opercle height were also provided. SPSS 20.0 Packaged Software and Excel 2010 Programmes were used for statistical calculations.

Results

Total length, opercle length and opercle height ranged from 11.6 to 24.7 cm, 10.04 to 24.32 mm, 9.23 to 20.67 mm, respectively. Descriptive statistics for total length and opercle dimensions were shown in Table 1.

The results of the statistical estimates indicated that the linear model had higher regression coefficient than the power model for both relationships between total length-opercle length and total length-opercle height. The estimated regression coefficients were 0.951 ($p < 0.001$) and 0.936 ($p < 0.001$), respectively. In addition, total length-opercle length and total length-opercle height relationships were calculated separately for right and left opercles (Figures 2-5).

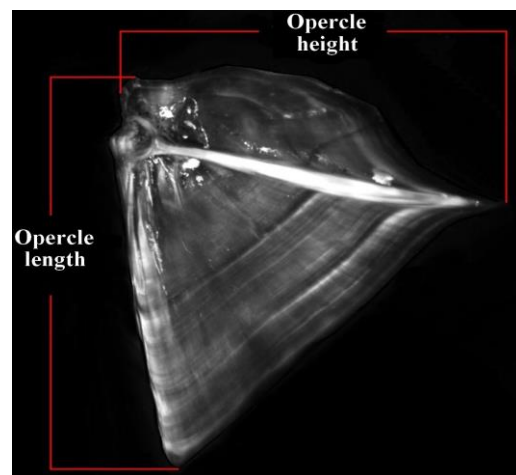


Figure 1. Measurements of opercle dimensions.

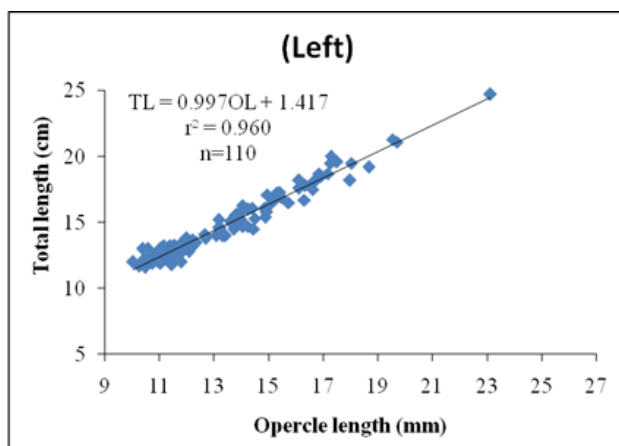
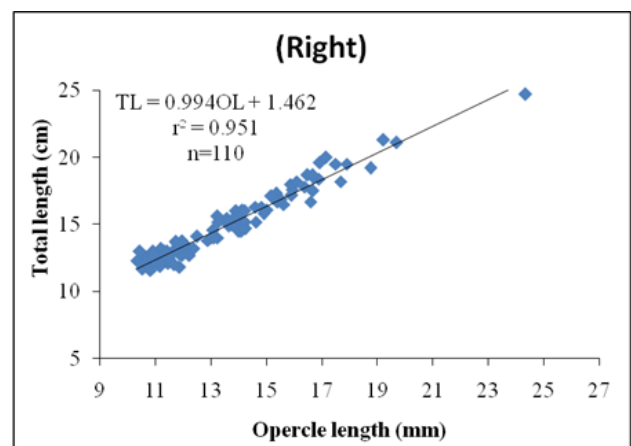
Equation parameters and models of the relationships are presented in Table 2. When right and left opercles were compared we found that there was a significant distinctness in terms of opercle length ($p < 0.001$) but there was no significant difference in terms of opercle height ($p > 0.05$).

Table 1. Descriptive statistics of *P. fluviatilis* from Lake Ladik ($n=110$).

Descriptive Statistics	TL(cm)	OL (right) (mm)	OL (left) (mm)	OH (right) (mm)	OH (left) (mm)
Mean	14.8	13.45	13.46	12.43	12.29
Minimum	11.6	10.33	10.04	9.23	9.30
Maximum	24.7	24.32	23.12	20.67	20.58
S.D.	2.52	2.48	2.48	2.15	2.14
S.E.	0,24	0.24	0.24	0.21	0.21

Table 2. Equation parameters of opercle dimensions-fish length relationships.

Variable	Aspect	Type of relationship	a	b	r^2	p
TL-OL	Left	Linear	1.417	0.997	0.960	$p<0.001$
		Power	1.447	0.896	0.954	$p<0.001$
	Right	Linear	1.462	0.994	0.951	$p<0.001$
		Power	1.420	0.903	0.946	$p<0.001$
TL-OH	Left	Linear	0.784	1.143	0.939	$p<0.001$
		Power	1.398	0.941	0.932	$p<0.001$
	Right	Linear	0.703	1.137	0.936	$p<0.001$
		Power	1.395	0.938	0.926	$p<0.001$

**Figure 2.** Total length-opercle length (left) relationships of *P. fluviatilis*.**Figure 3.** Total length-opercle length (right) relationships of *P. fluviatilis*.

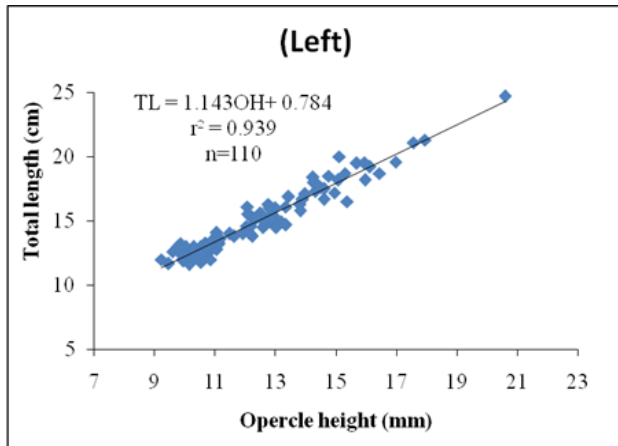


Figure 4. Total length-opercle height (left) relationships of *P. fluviatilis*.

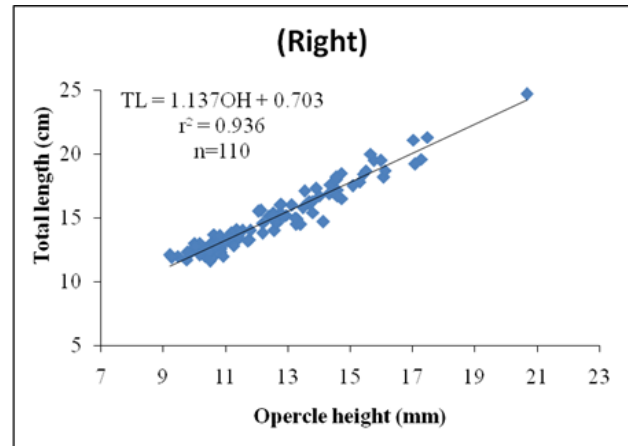


Figure 5. Total length-opercle height (right) relationships of *P. fluviatilis*.

Discussion

There have been a number of researches about the age, growth, reproductions, and the diet of perch (Polat and Kır 1996; Ceccuzzi et al. 2011; Yılmaz et al. 2013; Saygin 2013). However, a few studies were conducted on the fish length-bony structures relationships of this species (Copp and Kováč 2003; Yılmaz et al. 2014).

In this study, linear and power models were used for define relationships between fish length and opercle dimensions. It was obtained that regression coefficients were highly significant for all relationships ($r^2 > 0.92$). Linear models are higher regression coefficients than power models. Similar results were also obtained by Copp and Kováč (2003). Copp and Kováč (2003) examined the relationships between the fish length and left/right opercle length using linear regressions. They calculated regression coefficients (r^2) as 0.95 for both left operculum and right operculum. Different bony structures were also used for back-calculations of the perch's total length. Yılmaz et al. (2014) investigated the relationships between otolith dimensions and the total length of perch inhabiting Lake Ladik. They found regression coefficients higher than 0.78 using power models.

When right and left opercles were compared, we found that there was a significant distinctness in terms of opercle length ($p < 0.001$). So, right and left opercles should be distinguished in estimation of the total length. We recommend that this diversity be considered in the next studies about this species. Yılmaz et al. (2014) investigated distinctness of right and left otolith measurements and indicated that there was no significant difference between right and left otolith measurements.

Consequently, opercle length is a powerful tool for estimating the total length of the European perch inhabiting Lake Ladik. *E. lucius* and *P. fluviatilis* are

economically important fishes for this Lake. Individuals and bony structures of perch were removed from the stomachs of perch showing cannibalism as well as from the stomachs of pike (Yazicioglu 2014). The estimation of the total length of this species is important to understand the nutritional features of perch and pike in Lake Ladik.

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