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ARAŞTIRMA MAKALESİ RESEARCH PAPER

The Relationships Between Otolith Dimensions-Total Length and Otolith Features of European Perch (*Perca fluviatilis* L.,1758) Sampled from Yedikır Dam Lake (Turkey)[*]

Canan ŞİMŞEK* Nazmi POLAT Melek ÖZPİÇAK
Semra SAYGIN Savaş YILMAZ

Ondokuz Mayis University, Arts and Sciences Faculty, Biology Department, Samsun, Turkey
: https://orcid.org/0000-0001-9923-1316, : https://orcid.org/0000-0001-9785-9927, : https://orcid.org/0000-0003-3506-4242
: https://orcid.org/0000-0002-3249-5074, : https://orcid.org/0000-0003-2859-4886

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Atıf yapmak için: **Şimşek, C., Polat, N., Özpiçak, M., Saygın, S. & Yılmaz, S. (2019).** Yedikır baraj gölü (Türkiye)'nden örneklenen tatlısu levreği (*Perca fluviatilis* L.,1758)'nın otolit özellikleri ve otolit boyutları-total boy arasındaki ilişkiler. *Anadolu Çev. ve Hay. Dergisi,* ***4***(3), 348-353.

Abstract: This study aims to determine the otolith characteristics of European perch living in Yedikir Dam Lake and to reveal the relations between total length and otolith dimensions. 195 fish samples were captured from Yedikir Dam Lake were measured for total, fork and standard lengths and weighted. Sagittal otoliths were removed by making the left and right distinctions. Otoliths were photographed on the distal side and weighted (OW). Otolith length (OL) and breadth (OB) were measured with Leica Application Suit Ver. 3.8 image analysis program. Power ($y=ax^b$) and linear ($y=a+bx$) models were applied to estimate the relationships between the otolith measurements (OB, OL, OW) and total length (TL). There was no difference in OB, OL and, OW between the right and left otoliths of *P. fluviatilis* (P>0.05), but it was found that the otoliths of the female and male were significantly different (P<0.05). The relationships between otolith measurements and TL were determined to be quite significant (P<0.001). r^2 values of the relationships were changed between 0.957-0.969. The relationship between TL-OL in females, males and all individuals were found to be stronger than the others. This data is important in fishery biology studies. In recent years, studies on otolith morphology are quite common. The formation and growth of otolith are related to the growth of the fish. It is thought that this study will provide data to be carried out concerning perch and especially to be used in stock separation studies.

Keywords: Otolith features, *Perca fluviatilis*, total length, Yedikır dam lake.

Yedikır Baraj Gölü (Türkiye)'nden Örneklenen Tatlısu Levreği (*Perca fluviatilis* L.,1758)'nin Otolit Özellikleri ve Otolit Boyutları-Total Boy Arasındaki İlişkiler

Öz: Bu çalışmanın amacı Yedikır Baraj Gölü'nde yaşayan tatlısu levreğinin otolit özelliklerinin belirlenmesi, total boy ve otolit özellikleri arasındaki ilişkilerin ortaya çıkarılmasıdır. Yedikır Baraj Gölü'nden yakalanan 195 adet örneğin total, çatal ve standart boyları ölçülmüş, ağırlıkları tartılmıştır. Sagittal otolitler sağ ve sol ayrımları yapılarak çıkarılmıştır. Otolitler distal yüzeylerinden fotoğraflanmış ve ağırlıkları (OA) tartılmıştır. Daha sonra otolitlerin en (OE) ve boy (OB) ölçümleri Leica Application Suit Ver. 3.8 marka görüntü analiz programı ile ölçülmüştür. Otolit ölçümleri ile total boy arasındaki ilişkilerin hesaplanması için (TB-OE, TB-OB, TB-OA) doğrusal ($y=a+bx$) ve üssel regresyon ($y=ax^b$) modelleri uygulanmıştır. *P. fluvialitis* türünün sağ ve sol otolitleri arasında OE, OL ve OA bakımından fark olmadığı (P>0,05) ancak dişi ve erkek bireylerin otolitleri arasında önemli derecede fark olduğu tespit edilmiştir (P<0,05). Otolit ölçümleri ve TB arasındaki ilişkilerin oldukça önemli olduğu belirlenmiştir (P<0,001). İlişkilerin r^2 değerleri 0,957-0,969 arasında değişmiştir. Dişi, erkek ve tüm bireylerde TB-OB arasındaki ilişki diğerlerinden daha kuvvetli bulunmuştur. Bu veriler balıkçılık biyolojisi çalışmalarında önem taşımaktadır. Son yıllarda otolit morfolojisi ile ilgili çalışmalar oldukça yaygındır. Otolitin oluşumu ve büyümesi, balığın büyümesi ile ilişkilidir. Bu çalışmanın tür ile ilgili olarak gerçekleştirilecek çalışmalara veri sağlaması ve özellikle stok ayrım çalışmalarında kullanılması düşünülmektedir.

Anahtar sözcükler: Otolit özellikleri, *Perca fluviatilis*, total boy, Yedikır baraj gölü.

[*] *Bu çalışma Canan Şimşek'in Yüksek Lisans tezinden türetilmiştir.*
[*]*This manuscript is derived from Canan Şimşek's master thesis.*

INTRODUCTION

Otoliths have consisted calcium carbonate located at the inner ear of bony fishes and also they are considered as a true biological and environmental archive of fish life history. Therefore, otoliths are used in different types of studies such as age determination, species identification and discrimination, larval fish ecology, migration of fishes etc (Brazner et al., 2004; Campana, 2005; Popper et al., 2005; Secor, 2010; Huang et al., 2017; Lin et al., 2017; Prichard et al., 2018). This calcified structure shows phenotypic plasticity as inter- and/or intra-specific and inter- and/or intra-populations variations (Annabi et al., 2013; Mejri et al., 2018). Accordingly, the otolith characteristics of the same species living in different locations should also be known.

Morphological and morphometric characteristics of otoliths comprise an important instrument for species identification (Tuset et al., 2008). There are some studies which focused on ecomorphology studies (Volpedo & Echeverría 2003), fish species identification (Tuset et al., 2008), the revision of fish taxa (Dönel & Yılmaz, 2016), determination of the relationships between fish and otolith growth (Doğan & Şen, 2017) and determination of similarities between the fossil and modern fish species (Woydack & Morales-Nin, 2001). Otolith morphology varies between species, however separate stocks of the same species, often identical physically can sometimes be discriminated through subtle differences in otolith morphometrics (Tuset et al., 2003; Zengin et al., 2015; Ibáñez et al., 2017; Mapp et al., 2017). When the relationship between otolith dimensions and total length in a species is determined, the total length or standard length of a fish from its otolith dimensions can be estimated, or vice versa (Şen et al., 2001; Battaglia et al., 2010; Başusta et al., 2013; Yilmaz et al., 2014; Saygın et al., 2017; Yazicioğlu et al., 2017; Zengin et al., 2017; Ozpicak et al., 2018; Souza et al., 2019).

In this study, the relationships between otolith dimensions and total length of European perch, *Perca fluviatilis* (L., 1758) sampled from Yedikır Dam Lake were investigated. The European perch is the most common and widely distributed member of the Percidae. 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). In Turkey, European perch is reported from the lakes in Marmara Region, Black Sea Basin, Ladik Lake, Bafra Balık Lake and streams from Samsun, Terme and Bafra regions (Geldiay & Balık, 2007; Beğburs, 2010). This study aimed to detect the relationships between the total length and otolith dimensions of *P. fluviatilis* sampled from Yedikır Dam Lake.

MATERIAL and METHODS

Sampling: P. fluviatilis samples obtained from the Yedikır Dam Lake (40˚47'10.80" N and 35˚33'50.67" E) (Figure 1). SAMUS 725 MP shocker was used to capture fish samples. Samples were collected between December 2015-April 2017.

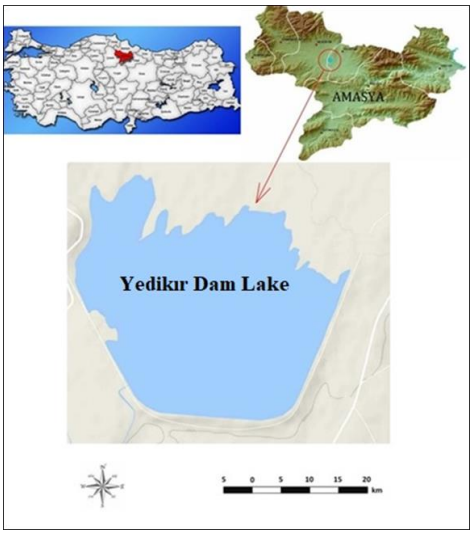

Figure 1. The map of Yedikır Dam Lake

Biological study: The systematic positions of the samples were determined using various identification keys (Geldiay & Balık, 2007; Kottelat & Freyhof, 2007; Polat & Uğurlu, 2011). All captured fish were measured to the nearest 0.1 cm for total length (TL), fork length (FL), standard length (SL) and weighted to the nearest 0.01 g. The sex was determined by macroscopic examination of the gonads. Sagittal otoliths were removed by making left and right distinctions. Otoliths were weighted using Precisa scales (OW) (± 0.0001 g). All otoliths were photographed on the distal side with a Leica DFC295 digital camera. Otolith breadth (OB) and length (OL) (± 0.001 mm) were determined by Leica Application Suit Ver. 3.8 Imaging Software. OL was defined as the greatest distance between anterior and posterior edges, and OB was defined as the greatest distance from dorsal to ventral edges (Stevenson & Campana, 1992; Battaglia et al., 2010) (Figure 2). The evaluations were performed separately for female, male and all individuals.

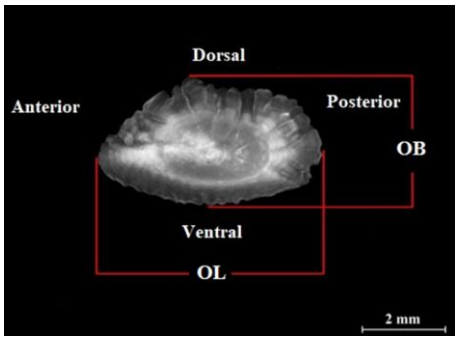

Figure 2. Otolith Length (OL) and Otolith Breadth (OB) of sagitta (Left otolith).

Statistical analysis: Linear and nonlinear models were applied to estimate the relationships between the otolith measurements (OL, OB, OW) and TL.

$y=ax^b$ and $y=a+bx$

where y is otolith measurement and x is fish length (Zar, 1999).

However, in evaluating the relationships between TL and otoliths dimensions, the power model is preferred because of its higher r^2 values. All data were tested by Kolmogorov-Smirnov if the data is normally distributed or not. Statistical analyses tested by Paired t-test, Wilcoxon test, Independent Two-Sample t test, Mann-Whitney U test. SPSS 20, Minitab 17.0 and the Excel software were utilized in the evaluation of data.

RESULTS

In this study, a total of 195 European perch samples (109♀ and 86♂) were investigated in terms of otolith dimension and total length relationships. The minimum-maximum total lengths and weights of the individuals vary between 4.5-24.0 cm and 0.98-210.22 g, respectively (Table 1). When sagittal otoliths of female and male were compared, there were differences in terms of OL, OB and OW ($P<0.05$). However, according to left and right otoliths comparisons, there were no differences ($P>0.05$) (Table 2). In this study right otoliths were used in the analysis. Descriptives of otoliths were shown in Table 3.

Table 1. Descriptive statistics of *P. fluviatilis*

Sex	N	Total Length (cm)					Weight (g)				
		Mean	±SE	±SD	MIN	MAX	Mean	±SE	±SD	MIN	MAX
F	109	8.178	0.369	4.244	4.576	23.7	15.85	3.11	35.76	0.98	199.74
M	86	9.925	0.398	4.056	5.845	24.0	21.04	3.22	32.83	2.17	210.22
F+M	195	8.948	0.276	4.243	4.576	24.0	18.14	2.25	34.52	0.98	210.22

(F: Female, M: Male, Min: Minimum, Max: Maximum, SE: Standard error, SD: Standard deviation).

Table 2. Statistical comparisons for right-left otolith pairs and sex.

Comparison type	Variable	Test	P
Right-Left	OL	Wilcoxon t Testi	P>0.05
	OB	Wilcoxon t Testi	P>0.05
	OW	Wilcoxon t Testi	P>0.05
Male-Female	OL	Mann-Whitney U Testi	**P<0.05**
	OB	Mann-Whitney U Testi	**P<0.05**
	OW	Mann-Whitney U Testi	**P<0.05**

Table 3. Descriptives of otolith characteristics for *P. fluviatilis*.

Sex		Mean	±SE	±SD	MIN.	MAX.	N
Female	OL	2.416	0.096	0.998	1.420	5.882	109
	OB	1.298	0.048	0.500	0.809	3.167	
	OW	0.0039	0.0005	0.0049	0.0007	0.0293	
Male	OL	3.0114	0.1074	0.9997	1.9150	5.9730	86
	OB	1.5636	0.5167	0.4791	1.0550	3.2320	
	OW	0.0060	0.0006	0.0056	0.0018	0.0306	
Female+Male	OL	2.6790	0.7430	1.038	1.4200	5.9730	195
	OB	1.4153	0.0363	0.5071	0.8090	3.2320	
	OW	0.0048	0.0004	0.0054	0.0007	0.0306	

Relationships between TL and OL, OB, OW were determined using the power regression equation and the best fit was obtained among TL-OL for the female, male and all population (r^2 >0.974). The equations representing the relationship between total length and otolith characteristics of European perch were separately determined for the female, male and all population (Table 4)

Table 4. Relationships between TL and otolith characteristics of *P. fluviatilis.*

Sex	Equations	a	b	r^2	P
F	TB-OW	2.886	2.200	0.957	<0.001
	TB-OB	0.248	0.793	0.970	<0.001
	TB-OL	0.391	0.870	0.974	<0.001
M	TB-OW	6.139	1.899	0.974	<0.001
	TB-OB	0.300	0.714	0.967	<0.001
	TB-OL	0.470	0.801	0.977	<0.001
F+M	TB-OW	3.575	2.115	0.960	<0.001
	TB-OB	0.263	0.768	0.969	<0.001
	TB-OL	0.409	0.855	0.974	<0.001

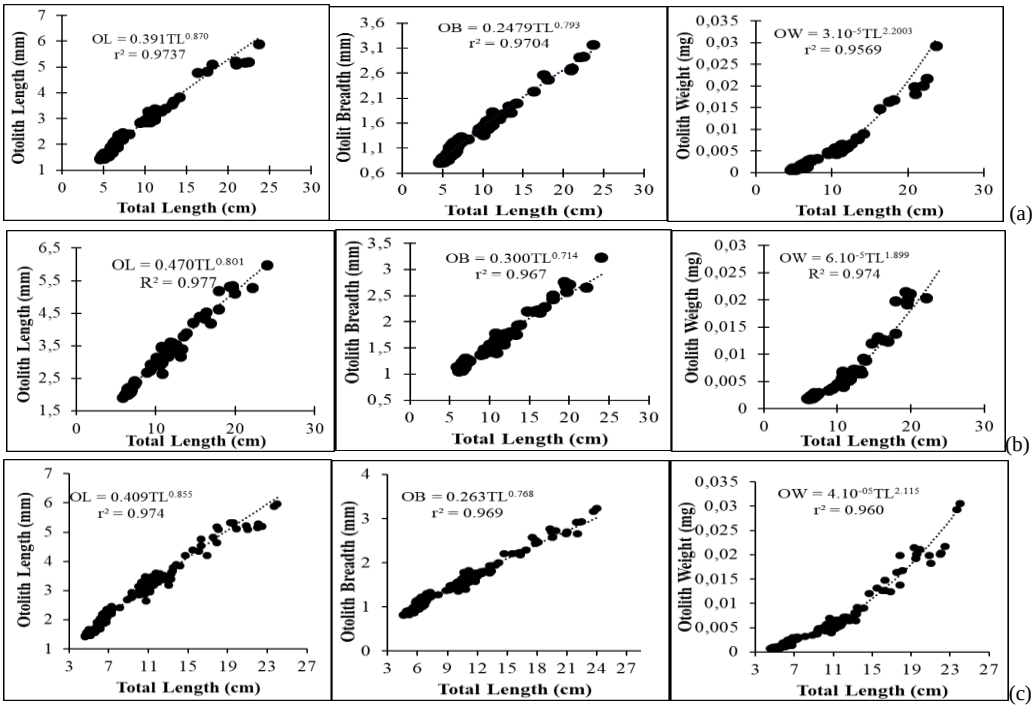

Figure 3. Relationships between otolith characteristics and total length for Yedıkır dam lake (a: Female, b: Male, c: All population).

DISCUSSION

Otolith morphometrics reflects phenotype and development stage and is influenced by factors such as sex, body condition, age, year-class, and stock as well as local environmental conditions (Mérigot et al., 2007; Vignon & Morat, 2010). In the past, otolith morphology has been useful for taxonomic identification in many fish species (Bergenius et al., 2006; Jawad et al., 2017). Recently, there are a lot of study about otolith shape, relationships between length and otolith morphometric in the literature (Leguá et al., 2013; Felix et al., 2013; Dörtbudak & Özcan, 2015; Bostancı et al., 2015; Bose et al., 2017; Jawad et al., 2017; Zhao et al., 2017; Duncan et al., 2018; Saygın et al., 2017; Zengin Özpiçak et al., 2018).

In this study, a significant difference was found between the sagittal otoliths of female and male of perch in terms of the OL, OB and OW sampled from Yedikır Dam Lake ($P<0.05$). Yilmaz et al. (2014) investigated the relationships between otolith dimensions and body length of European perch from Lake Ladik and correlatively, found that there were differences in OL, OB, and OW between female and male. Besides, studies performed with other fish species show significant differences in otolith measurements between male and female individuals, too (Munday et al., 2004; Vallisneri et al., 2008; Bostancı et al., 2009; Kontaş & Bostancı, 2015,). However, Yilmaz et al. (2014) found that left and right otolith pairs were not statistically different in terms of OL, OB and OW ($P>0.05$). In this study, when right and left otolith were compared, there were no significant differences in terms of otolith length, otolith breadth and weight, too ($P>0.05$). There are also different studies which show no difference between right and left otoliths (Jawad et al., 2011; Zengin et al., 2015; Saygın et al., 2017; Zengin et al., 2017).

Relationships between otolith dimensions and fish length are commonly used in fisheries science. Also, otolith studies particularly have a very important place in species identification from the discovery of fossiliferous layers in archaeological sites and prey-predator relations (Tuset et al., 2008). Fish size and/or weight can be functionally related to an appropriate otolith measurement and the resulting relationships can subsequently be used for size estimation (Pierce et al., 1991; Tollit et al., 1997; Granadeiro & Silva, 2000). Fish size-otolith size relationships will be useful for researchers examining food habits of piscivores and size of fish in archaeological samples (Harvey et al., 2000). The relationships between TL and otolith measurements of fish species could provide info for the back-calculation of the fish total length from otolith measurements (Zan et al., 2015). In this study, otolith length was found to be the best indicator for estimating the length of fish. OL and TL relationships were strong from other relationships ($r^2>0.974$). And also, Yilmaz et al. (2014) were found a strong relationship between total length and otolith length, too. r^2 values were determined as 0.869 and 0.815 in male and female individuals, respectively. It is a known fact that there is a relationship between the size of the fish and the bony structures.

Generally, in different studies that examined the relationship between fish length and otolith dimensions, OL was detected as a strong parameter for estimating fish length (Granadeiro & Silva, 2000; Bostancı, 2009; Cengiz et al., 2012; Felix et al., 2013; Zengin et al., 2015; Yilmaz et al., 2015; Pavlov, 2016; Kanjuh et al., 2018; Park et al., 2018).

The present study provides a baseline for European perch and indicates that OL is a strong predictor for fish length. This data will help investigators studying food habits of top predators to determine the size of prey fish from the length of recovered otoliths.

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***Corresponding author's:**
Canan ŞİMŞEK
Ondokuz Mayıs Üniversitesi, Fen-Edebiyat Fakültesi, Biyoloji Bölümü, Samsun, Türkiye.
E-mail : cananssimsek@gmail.com
ORCID : https://orcid.org/0000-0001-9923-1316
Tel : +90(362) 312 19 19-5504
Fax : +90 (362) 457 60 81
GSM : +90(544) 584 39 13