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Main Growth Parameters of a Threatened Species *Chondrostoma holmwoodii* (Boulenger, 1896) from Tahtalı Reservoir, İzmir, Turkey

Mustafa KORKMAZ*, Fatih MANGIT, Sedat Vahdet YERLİ

Hacettepe University, Science Faculty, Departmant of Biology, SAL, Ankara, Turkey

ABSTRACT

A diverse genus of the Cyprinidae family, genus *Chondrostoma* Agassiz, 1832 has a wide distribution. More than half of the species distributes in Turkey, however there is little biological information about them. The aim of this study is to investigate the population parameters of Eastern Aegean Nase *Chondrostoma holmwoodii* and to evaluate the risks for the species in Tahtalı Reservoir. Fish sampling was carried out at 8 different sampling points at Tahtalı Reservoir in 2014 with multimesh gillnets. Population parameters such as age and sex composition, length frequence analysis and von Bertalanffy growth function were investigated. A total of 215 specimens of *C. holmwoodii* was sampled. Total length of the specimens varies between 4.3 - 28.2 cm and total weight 1.05 - 271 g. Age composition of the sampled specimens varies between 0 to V and most of the specimens were age-III. The von Bertalanffy growth parameters for *C. holmwoodii* was estimated as; L_∞= 395.30 mm (SD=63.80), K=0.17 (SD=0.05) and L_0=46.45 mm (SD=9.41). In conclusion, main problem for *C. holmwoodii* population in Tahtalı Reservoir is predation risk by *Perca fluviatilis* Linnaeus, 1758. In order to offer conservation strategies for *C. holmwoodii* Tahtalı Reservoir population, diet, population structure, and life history traits of *P. fluviatilis* need to be studied in detail.

Keywords: Eastern Aegean Nase, *Chondrostoma holmwoodii*, endemic fish, von Bertalanffy.

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* ***CORRESPONDING AUTHOR***

korkmaz.hidro@gmail.com
Tel : +90 312 297 67 85

Nesli Tehlike Altında Olan *Chondrostoma holmwoodii* (Boulenger, 1896)'nin Tahtalı Baraj Gölü'ndeki Büyüme Parametreleri

Öz: Cyprinidae familyasına ait *Chondrostoma* Agassiz, 1832 cinsi geniş dağılım alanına sahiptir. *Chondrostoma* türlerinin çoğu Türkiye'de dağılım göstermesine rağmen biyolojileri hakkında yeterince bilgi bulunmamaktadır. Bu bağlamda *Chondrostoma holmwoodii*'nin Tahtalı Baraj Gölü'ndeki popülasyon parametrelerini incelemek ve mevcut popülasyonun risklerini değerlendirmek bu araştırmanın amacını oluşturmaktadır. Balık örnekleri 2014 yılında Tahtalı Baraj Gölü'nde belirlenen sekiz farklı örnekleme noktasından çokgözlü ağlar ile örneklenmiştir. Yaş ve cinsiyet kompozisyonu, boy frekans analizi ve von Bertalanffy büyüme fonksiyonu gibi popülasyon parametreleri araştırılmıştır. *C. holmwoodii*'nin total boyu 4,3 – 28,2 cm ve toplam ağırlığı 1,05 - 271 g arasında değişen 215 bireyi örneklenmiştir. Örneklenen bireylerin yaş kompozisyonu 0 ile V arasında değişirken popülasyondaki baskın yaş III olarak tespit edilmiştir. Ayrıca von Bertalanffy büyüme parametreleri; L_∞ = 395,30 mm (SS = 63,80), K = 0,17 (SS = 0,05) ve L_0 = 46,45 mm (SS = 9,41) olarak tespit edilmiştir. Sonuç olarak, Tahtalı Barajı Gölü'ndeki *C. holmwoodii* popülasyonu için temel tehditin *Perca fluviatilis* Linnaeus, 1758'in tür üzerindeki predasyon baskısı olduğu görülmüştür. *C. holmwoodii*'nin Tahtalı Baraj Gölü popülasyonu için koruma stratejileri belirlenirken *P. fluviatilis*'in diyet, popülasyon yapısı ve yaşam öyküleri de incelenmelidir.

Anahtar kelimeler: Kababurun balığı, *Chondrostoma holmwoodii*, endemik balık, von Bertalanffy

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Introduction

A diverse genus of the Cyprinidae family, genus *Chondrostoma* Agassiz, 1832 distributed throughout south and central Europe, Anatolia, the Caucasus and Mesopotamia (Elvira 1997; Durand et al. 2003; Robalo et al. 2007). Complicated phylogenetic

relationships of the genus seem have been recently investigated by Robalo et al. (2007) and five new genera are described, namely *Achondrostoma*, *Iberochondrostoma*, *Pseudochondrostoma*, *Protochondrostoma* and *Parachondrostoma*. With the description of two new species from Turkey (Küçük et al. 2017) and accounting *C. fahirae* (Ladiges, 1960), *Chondrostoma* sensu stricto comprises 22 species (Robalo et al. 2007; Küçük et al. 2017).

A total of 12 species distributed in Turkey (Krupp 1985; Küçük et al. 2007; Freyhof and Özuluğ 2009; Küçük et al. 2013; Kuru et al. 2014; Küçük et al. 2017) however there is little biological information about them. To our knowledge, length-weight relationship and growth of *Chondrostoma regium* (Heckel, 1843), *Chondrostoma holmwoodii* (Boulenger, 1896), *Chondrostoma kinzelbachi* Krupp 1985 and *Chondrostoma meandrense* Elvira, 1987 are present (e.g. Yüce et al. 2015; Oymak 2000; Suiçmez et al. 2011; Gürleyen et al. 2012; Özcan and Balık 2011; Balık et al. 2007; İlhan et al. 2010; Yerli et al. 2016).

Evaluation of life history traits of a threatened species can be an important tool to identify population trends, leading to take successive management actions for conservation (Park et al. 2003; Riberio et al. 2008). They are also valuable tool for fisheries biologists to determine the effects of exploitation on economic fish species (Jennings et al. 1999) or by policy makers to determine the time/limits of fishing activities (Redpeth et al. 2009). In addition to these, life history traits are being used in order to predict the probability of success of invasive/introduced species (Rosecchi et al. 2001; Copp et al. 2016).

Growth is a critical trait causing determination of population demography, evolution and community interactions (Urban 2007). However, some serious critics about the model has been reviewed (Roff 1980), the von Bertalanffy growth function is the most commonly used growth function in fisheries analyses (Haddon 2011).

Tahtalı Reservoir is an important drinking water supply for İzmir province and in order to keep water quality of the lake in the desired limits, alternative land use politics have been investigated (Ay 2001). In addition to these, lake is also highly protected for fisheries activities. A total of 8 species distributes in the lake (OSİB SYGM 2015). One of the residents of the lake, *C. holmwoodii* is listed under Vulnerable (VU) status and it has been reported that population size and also mature individuals are decreasing (Freyhof 2014)

Aim of this study is to investigate the population parameters of the threatened species *C. holmwoodii* in Tahtalı Reservoir, located in Küçük Menderes River Basin, İzmir, Turkey, report growth parameters for the species and compare results with other studies.

Materials and Methods

Fish sampling was carried out at eight sampling stations at Tahtalı Reservoir. Sampling was conducted at three different seasons, spring, summer and fall in 2014. Multimesh gillnets with 12 different mesh size ranging between 5 mm to 55 mm were used according to modified TS EN 14757. Dead specimens following sampling were fixed in a 4 % formalin solution and transferred to alcohol after fixation. Insize digital caliper was used to measure the total length (TL; cm) and digital scale to measure weight (W; g). Sex determinations were done with visual examination of the gonads of the sampled specimens.

Age-Length

Scales between lateral line and dorsal fin were used for determination of age. More than 25 % of the sampled specimens (n:54), covering total length range of the sample were aged by three independent readers. The multinomial logistic regression model (Gerritsen et al. 2006) from 'nnet' package (Venables and Ripley 2002) developed for R 3.4.0 (R Core Team 2014) was used to predict ages of the unaged specimens.

Growth Model

Due to low sample size of small specimens, von Bertalanffy growth function by von Bertalanffy (1938) was used in where t_0 is replaced by L_0;

$$E\{L|t\} = L_\infty - (L_\infty - L_0)\, e^{-Kt}$$

In the equation, $E\{L|t\}$ is the mean length at age t and L_∞, K, L_0 are the coefficients to be estimated from the function, they represent asymptotic length (L_∞), relative growth coefficient (K) and theoretical length when fish age is zero (L_0).

Results from the model were then bootstrapped and given in histograms with confidence intervals. All analyses were conducted with FSA package (Ogle 2014) developed for R 3.4.0 (R Core Team 2014).

Results

A total of 215 specimens of *C. holmwoodii* was sampled. Total length of the specimens varies between 4.3 cm and 28.2 with a mean value of 19.17 cm (SD=0.42) and total weight (W) varies between 1.05 and 271 g. According to a subset of 92 specimens, female/male ratio is 1.00/0.94 and 16 of

them were identified as immature. Deviation from 1:1 ratio is not significant at p<0.05.

Age-Length

Age of all specimens were predicted from the aged specimens (n:54). Age composition of the sampled specimens varies between 0 to V. Total length variability of the age groups is illustrated at Figure 1 and given in detail in Table 1.

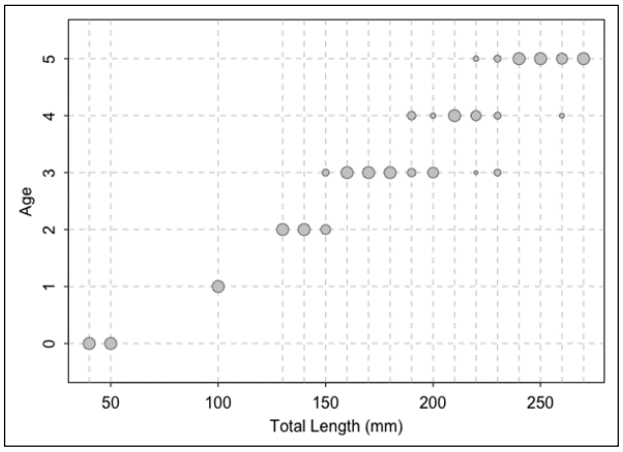

Figure 1. Age-Length of the *C. holmwoodii* in Tahtalı Reservoir (Dot size indicate percentages)

Table 1. *C. holmwoodii* mean total lengths at age

Age	n	Mean TL (cm)	*SD*	*SE*
0	13	63.5	19.8	5.48
I	1	104.0	NA	NA
II	29	148.0	6.33	1.18
III	71	189.0	24.16	2.87
IV	48	219.0	16.11	2.33
V	53	249.5	13.83	1.90

Most of the specimens (33%) were age-III with a mean total length of 189 mm (SD=24.16). Mean length of second lowest age, which was found out to be age-0, was 63.5 mm (SD=19.8). Only one specimen was found to be age-I. Total length of the 29 (6 %) age-II specimens were 148 mm with a standard deviation of 6.33 mm. Mean total length of age IV and V specimens were found out to be 219 (SD=16.11) and 249.5 (SD=13.83) mm respectively.

Growth Model

The von Bertalanffy growth parameters for *C. holmwoodii*, Tahtalı Reservoir population were estimated as: L_∞= 395.30 mm (SD=63.80), K=0.17 (SD=0.05) and L_0=46.45 mm (SD=9.41). Parameter estimates are summarized in Table 2.

Bootstrapped von Bertalanffy growth parameter results were given as histograms in Figure 2 with confidence intervals. Residuals of the model fit with frequencies shown in Figure 3.

Relationships between parameter estimates are as follows; $K - L_\infty$ =-0.99, $L_\infty - L_0 = 0.54$, $K - L_0 = -0.64$. Low correlation values indicate less dependent parameter estimates.

Table 2. von Bertalanffy growth paramater estimates for *C. holmwoodii*

	Estimate	SE	t value	p
L_∞	395.3004	63.7983	6.196	< 0.001
K	0.1758	0.0512	3.433	< 0.001
L_0	46.4474	9.4087	4.937	< 0.001

Discussion

Reviewing the extent literature is beyond the scope of this study however, using different parameterizations, controlling correlations between model parameters is gaining a momentum. Fitting fish growth data with a von Bertalanffy growth function is really hard, model fit can be inaccurate because of missing data (e.g. young classes) and characteristics of the model (Ogle 2016). In order to deal with lack of young fish classes (Age I), original version of the model where t_0 is replaced with L_0, is used in this study rather than Beverton (1954). According to Cailliet et al. (2006) L_0 has serious advantages over t_0, especially for evaluation of fit. According to an experimental study with *C. nasus*, length after 63 days of hatch is averagely 3.47 cm (Schludermann et al. 2009). Our estimate of L_0=4.65±0.94 cm seems to represent not the best but an acceptable fit.

Result of this study significantly differs from the results presented by İlhan et al. (2010). Authors reported $L_\infty = 29.19$ cm, t_0 = -3.258, k = 0.177 from a population whose fork length ranged between 13 – 24 cm. When we calculate L_0 from these values, it equals to 12.79 cm, which is larger than prediction of 4.65 cm. Also L_∞ results from this study is lower than prediction of 39.53 cm. These differences are probably due to sampling equipment selectivity. Specimens sampled in this study ranged from 4.3 cm to 28.2 cm and this range is probably giving a better estimation.

According to a study conducted with the same specimens allometric coefficient *b* of the *C. holmwoodii* was 3.04, the *b* value showed a significant deviation from value 3 ($p < 0.05$) indicating a positive allometry (Yerli et al. 2016). İlhan et al. (2010) reported that the *b* value for *C. holmwoodii* in Tahtalı Reservoir similar to this result (3.13). On the other hand, the *b* value of different species belonging to the genus *Chondrostoma* were 2.71, 2.76 and 3.24 for *C. meandrense*, *C. kinzelbachi* and *C. regium* respectively (Özcan and Balık 2011; Özcan and Altun 2016; Oymak 2000).

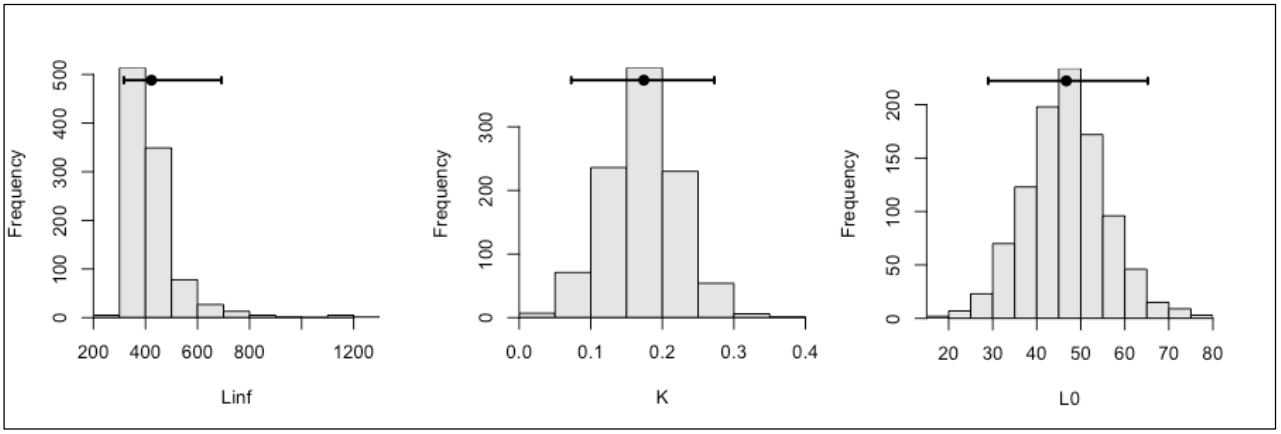

Figure 2. Frequency for bootstrapped von Bertalanffy growth parameters with confidence limits

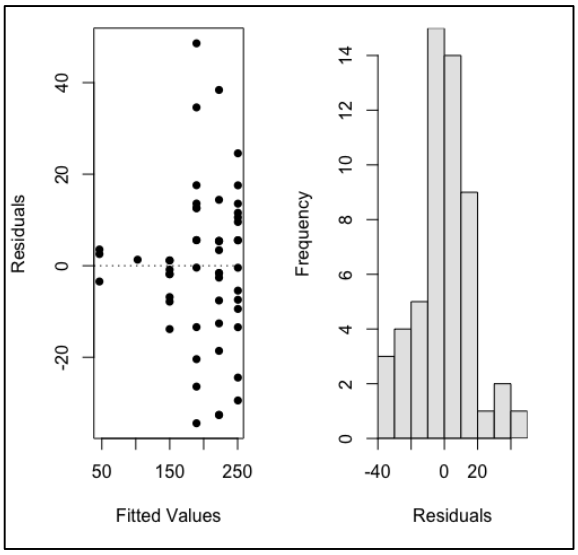

Figure 3. von Bertalanffy growth model fit with distribution of residuals

According to our observations, main problem for *C. holmwoodii* population in well protected Tahtalı Reservoir is predation risk by *Perca fluviatilis* Linnaeus, 1758. Multimesh gillnets sampled specimens from 4.3 cm to 28.2 cm; however, there is only one specimen between 10 – 13 cm range which falls to age I of the species. Similar observation was reported by İlhan et al. (2010). Lack of this age group might be due to evasion of young members of the population to deeper parts of the lake to avoid predation risk. Another possible explanation for this situation might be that this is a population response to decrease interspecific competition. However detailed predator-prey relationship studies need to be conducted in order to answer these questions and offer a conservation strategy.

In order to offer conservation strategies for *C. holmwoodii* Tahtalı Reservoir population, diet, population structure, and life history traits of *P. fluviatilis* need to be studied in detail. By this way, in addition to getting this important data about *P. fluviatilis*, its population size will be controlled too.

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