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Growth Biology of the Topmouth Gudgeon (Pseudorasbora parva) from Lake Mogan (Turkey)

Mogan Gölü (Türkiye)'ndeki Çizgili Sazancık (Pseudorasbora parva)'ın Büyüme Biyolojisi

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Abstract: *In this study, the growth biology of topmouth gudgeon, Pseudorasbora parva (Temminck & Schlegel, 1846), sampled from Lake Mogan, Ankara, Turkey were studied between July 2013 and June 2014. Length-weight relationship, von Bertalanffy growth equation, Fulton's condition factor and rational growth increase were evaluated from obtained data. Length-weight relationship was estimated as W=0.0138xTB2.8414(r2 = 0.948). von Bertalanffy Growth Model was calculated as Lt= 106.8495[1-e-0.212451(t+2.59075)]. Fulton's condition factor was found at the lowest level in fall and winter season, increasing the beginning of spring season due to the annual reproductive cycle.*
Key words: *Pseudorasbora parva, Lake Mogan, von Bertalanffy, condition Factor.*

Özet: *Bu çalışmada Temmuz 2013 ve Haziran 2014 tarihleri arasında Mogan Gölü, Ankara Türkiye'den örneklenen çizgili sazancık balığının, Pseudorasbora parva (Temminck & Schlegel, 1846), büyüme biyolojisi incelenmiştir. Uzunluk-ağırlık ilişkisi, von Bertalanffy büyüme denklemi, Fulton durumu elde edilen verilerden faktör ve rasyonel büyüme artışı değerlendirildi . Uzunluk-ağırlık ilişkisi W = 0.0138xTB2.8414 (r2 = 0.948) olarak hesaplandı. von Bertalanffy Büyüme Modeli, Lt = 106.8495 [1-e-0.212451 (t + 2.59075)] olarak hesaplandı. Fulton'un kondisyon faktörü, sonbahar ve kış mevsiminde en düşük seviyede bulunarak, yıllık üreme döngüsünden dolayı ilkbahar mevsiminin başlangıcını artırmıştır.*
Anahtar sözcükler: *Pseudorasbora parva, Mogan Gölü, von Bertalanffy, kondisyon faktör.*

1. Introduction

The topmouth gudgeon, *Pseudorasbora parva* (Temminck and Schlegel, 1846), is a small cyprinid fish originated from Middle Asia which is native in Amur Basin, Japan, China, Korea and Taiwan (Copp *et al.*, 2010). This invasive species was seen for the first time in Donube River (Romania) in 1960; then, spread very quickly throughout Europe (Pollux and Korosı§, 2006). It has now overspread at least 32 countries included Turkey (Hardouin *et al.* 2018). It was thought that the topmouth gudgeon was initially transported accidentally from the Chinese fish culture (*Ctenopharyngodon idella, Aristichthys nobilis* and *Hypophathalmichthys molitrix*) to Europe (Witkowski, 2011).

Pseudorasbora parva has high ecologic tolerance compared to other natural fish species including pollution, sudden temperature changes and low water levels (Pollux and Korosı§, 2006). Due to its short life time, several times reproduction in a year and high fertilization capacity indicates the species as highly invasive (Nowak and Szczerbik, 2009). In Europe, although studies are limited for the natural fish species and topmouth gudgeon relationship; it is well known that topmouth gudgeon feeds on other fish eggs, larvas and parasites carrying such as *Clonorchis sinensis* (Pak *et al.*, 2016), *Sphaerothecum destruens* (Adlard *et al.*, 2015), its negative effects on natural fish species (Pollux and Korosı§, 2006).

Compared to Europe and Middle East, Turkey is a very rich country in terms of biodiversity, leading to an important gene pool with high endemism and genetic variation; due to its biogeographical condition (European-Siberia, Iranian and Mediterranean) affected by differential seasons and topographic structures.

236 fish species and subspecies belonging to 26 families were identified in Turkey's freshwater (Kuru, 2004); meanwhile the number of species are increasing with a current estimate of 301 with the recent identified one (Ekmekçi *et al.*, 2013).

Previous studies indicate the presence invasive fish speciesin Turkey for over 50 years; in which *Pseudorasbora parva* was defined as one of them. This species recorded for the first time in Meriç River in Turkey by Erk'akan in 1982 (Ekmekçi *et al.*, 2013). After this, it was found in Aksu River (1997); Karacaören-I Dam (2001); Topçam Dam Lake (2003) ; Gelingüllü Dam Lake (2003); Dipsiz - Çine Creek (2004); Filyos – Devrek Creek (2006); Kirmir Creek and Sarıyar Dam Lake (2006); Yortanlı Creek (2006); Sarıçay (2006); Gölcük Lake (2006); Karacaören Dam Lakes (2006); Bekdeğin Pond (2007); Felek Creek (2008); Ağaçköy Creek (2008); Hirfanlı Dam Lake (2009); Akgöl (2010); Bayraktar Reservoir Lake (2012); Beyşehir Lake (2012); Gönen Creek (2012); Kirazoğlu Reservoir Lake (2012); Ula Reservoir Lake (2012); Meyil Lake (2013) and Evri Creek (2013) (Şaşı and Balık 2003, Kırankaya and Ekmekçi 2006, İlhan *et al.* 2013, Özuluğ *et al.* 2013). The researchers thought that the species were widely in Turkey's freshwater beacause of stocking fish in dam lakes by General Directorate of State Hydraulic Works (Yalçın-Özdilek *et al.*, 2013).

For the proper management of fish and fishery, it recording the population's age structure and growth rates have great importance. Age data values are important; since length and weight measurements are associated with age, stock composition, first maturity age, reproductive life, growth, death and the amount of product (Akbulut, 2008). Determination of fish age and growth relationship, it would provide positive or negative impacts about fishing in the area as well as the nutritional capacity of water since comparision of the same species at the same age in different water systems it would indicate potential differences (Özeren, 1997).

There are numerous researches on ecology, ecotoxicology, biology, reproduction and developmental stages from embryonic to larval of on topmouth gudgeon population (Adamek *et al.*, 1996; Allen *et al.*, 2006; Britton, 2008; Gao 2008; Grabowska, 2010; Fukuda, 2013; Onikura, 2013; Fu, 2014; Hasankhan, 2014; Ivancheva, 2014; Liu *et al.*, 2017; Chen *et al.*, 2018; Ma *et al.*, 2018; Zhu *et al.*, 2018); while information regarding growth biology is limited. Therefore, the aim of this study was to evaluate the growth biology of the topmouth gudgeon population from Lake Mogan in Ankara, Turkey.

2. Materials and Methods

2.1. Sampling Area

Lake Mogan (between 39° 44' 45'' N - 39°47' 45'' N and 32° 46' 30'' E - 32° 49' 30'' E), an alluvial set lake with 5.4 km^2 area, maximum depth 4 m and average depth 2,4 m is 20 km far away from Ankara (Demir *et al.* 2014). It is a RAMSAR conservation site because of shelter, nesting and accommodation of 227 bird species. Furthermore, there are 788 floral species (Taşeli, 2006) and fish species such as *Alburnus escherichi* (Sönmez, 1996), *Carassius auratus* (Seçer, 1995), *Alburnus alburnus* (Ozaktaş *et al.*, 2012).

2.2.Sampling preparation

The fish examined were collected monthly from July 2013 to June 2014. Samples were collected by seine used by fishermen, which have 0.7 mm mesh size. The specimens were brought to Ankara University Hydrobiology Laboratory in a 10 L jar with oxygen ventilation. On the ice anesthesia, fish's total length (TL), fork length (FL), standard length (SL) and total weight (W) were measured. Lengths and weight were measured by using 0.1 milimetric ruler and 0.1 g precision scales (Dikomsan

KD-TBC 1200). Age was determined based on fish scales. After the scales were taken between dorsal fin and line lateral, they were cleaned one by one using 4% NaOH (3 minutes), 70% ethyl alcohol (15 seconds), tap water (10 seconds) and placed between two slides to be examined under stereomicroscope (SOIF) for age determination. After dissection, sex was determined by macroscopic and microscopic observation.

2.3. Growth parameters

To determine growth biology, four methods were studied; length-weight relationship, von Bertalanffy growth function, Fulton's condition factor and rational growth increase.

2.3.1. Length-weight relationship

Estimation of length-weight relationship is important in fish biology for the assessment of fish pyhsiology and conservation. Population can grow either isometric, negative or positive allometric. As the fish grows, incase of no change in body shape indicate an isometric; increasing weight but in a slender shape indicate negative allometric; and increasing in both weight length indicate positive allometric growth (Nehemia, 2012).

Length-weight relationship equation is

$$W=axL^b$$

where W is total weight (g), L is total length (cm), a and b are regression coefficients.

2.3.2. von Bertalanffy Growth Function (VBGF)

The determination of fish population dynamics scientists developed growth models such as the re-parameterized Gompertz, the inverse logistic model and the von Bertalanffy model (Helidoniotis, *et al.* 2011). In this study, we chose von Bertalanffy model which is a commonly used model in fisheries sciences in order to provide a descriptive model of length-at-age data (Charles, 2010) and to determine the fish population dynamics along with the effects of fishery regulations on the catch (Roman-Roman *et al.* 2010).

The von Bertalanffy growth function (VBGF) is

$$L_t = L_\infty [1-e^{-k(t-to)}]$$

where L_t is the mean length at age, L_∞ is the asymptotic length, k is Brody growth coefficient, t is the age and t_0 is the time where length is zero. $L_{t\ and}$ L_∞ are dependent to fish species, habitat, age and genetic features (Yıldızbakan *et al.* 2005).

2.3.3. Fulton's Condition Factor K

Fulton's condition factor is used in fisheries research nursery habitat quality, morphometric condition index and the nutritional state of an individual fish.

Fulton's condition factor K equation is

$$K=(W/L^3)x100$$

where W is total weight (g) and L is total length (cm) (Schreck and Moyle, 2000).

2.3.4. Rational growth increase

This parameter is used to determine growth rate depending on age. Rational growth increase is at the beginning of any time period length and the amount of weight gain which is the ratio of height or weight values. Rational length increase equation is $OL=(L_t- L_{t-1})/(L_{t-1})$ and rational weight increase equation is $OW=(W_t- W_{t-1})/(W_{t-1})$.

2.4. Statistical analyzes

Significant differences were determined by one-way ANOVA test. For the entire statistical procedures the level of significance established was 0.005. The statistical tests were analyzed by SPSS 20.0 program.

3. Results

3.1. Population structure

Among 347 samples, 326 were male (37.46%) and 196 were female (56.48%); while due to not detected the sexual maturity, 21 samples (6.05%) could not be classified in terms of gender. Age was determined by scales, and four age classes were identified; 0+, 1+, 2+ and 3+. In age group 0+, among

9 specimens 2 were females and 3 were males. In age group 1+, among 139 specimens 59 were females and 64 were males. Group 2+, among 148 specimens 58 were females and 89 were males. Group 3+, among 51 specimens 11 were females and 40 were males. Almost 82.71% of specimens were in age classes 1+ and 2+. In age class 1+ females ratio were higher than males; while in age class 3+ males were higher. Total lengths and total weights were between 47 - 95 mm and 0.60 - 7 g, respectively.

Minimum, maximum and average total lengths classified into female, male and are shown in Table1. There were significant differences in the age classes 1+ and 2+ ($P<0.05$).

Table 1. Total length and age relationship *Pseudorasbora parva* population sampled from Lake Mogan

Total Length (mm)			
Age Class	Female	Male	Total
	mean ± SD (min-max)	mean ± SD (min-max)	mean ± SD (min-max)
0+	49.5 ± 0.07 (49 – 50)	47.7 ± 0.05 (47 - 48)	49.1 ± 4.9 (47 – 51)
1+	58.7 ± 5.1 (51 – 67)	59 ± 5.4 (49 – 67)*	58.7 ± 5.1 (49 – 67)
2+	68.8 ± 6.1 (61 - 83)	69.7 ± 6.4 (59 - 80)*	69.3 ± 6.1 (59 – 83)
3+	79.1 ± 7.7 (74 - 92)	79.7 ± 7.4 (70 – 95)	79.8 ± 7.5 (70 – 95)

*The asterisk (*) indicates significant differences ($P<0.005$)

Minimum, maximum and average total weights classified into female, male are shown in Table 2. Significant differences were especially in the age classes 1+ and 2+ ($P<0.005$).

Table 2. Total weight and age relationship of *Pseudorasbora parva* population sampled from Lake Mogan

Total Weight (g)			
Age Class	Female	Male	Total
	mean ± SD (min-max)	mean ± SD (min-max)	mean ± SD (min-max)
0+	1.16 ± 0.21 (0.99 – 1.3)	0.71 ± 0.12 (0.6 – 0.84)	0.9 ± 0.98 (0.6 – 1.3)
1+	1.62 ± 1.12 (1 - 2.95)	1.53 ± 1.74 * (0.8 – 2.66)	1.54 ± 1 (0.67 – 2.95)
2+	2.51 ± 1.71 (0.6 – 4.04)	2.6 ± 1.59 * (1 – 5)	2.56 ± 1.64 (0.6 – 5)
3+	4 ± 4.18 (2.31 – 6)	4.02 ± 5.37 (4.7 – 7)	4.02 ± 2.24 (2.17 – 7)

*The asterisk (*) indicates significant differences ($P<0.005$)

3.2. Growth parameters

3.2.1. Length-length relationship

The relationships between lengths were determined by using total, standard and fork lengths.

Total; $W=0.0138xTB^{2.8414}$ ($r^2 = 0.948$)

Female; $W=0.0071xTB^{3.1065}$ ($r^2 = 0.9317$)

Male ; $W=0.0065xTB^{3.0998}$ ($r^2 = 0.9396$)

According to these equations, b values were 2.8414 for total; 3.1065 for female and 3.0998 for male populations.

3.2.2. von Bertalanffy Growth Function (VBGF)

Growth parameters for describing the von Bertalanffy growth equation was calculated as:

$L_t= 106.8495[1-e^{-0.212451(t+2.59075)}]$.

$L\infty$ value was found as 106.8495 mm, k Brody growth coefficient 0.212451 and t_0 value was -2.59075.

Length-length relationships of specimens are presented in Table 3.

Table 3. Length- length relationships of *Pseudorasbora parva* from Lake Mogan

Species	Equation	Length- length characteristics		
		a	b	r^2
Pseudorasbora parva	FL=a+bxTL SL=a+bxTL SL=a+bxFL	-0.1181 -0.0888 0.0542	0.9 16 0.8144 0.8825	0.9884 0.9897 0.9866

3.2.3. Fulton's Condition Factor K

Age and condition factor relationship was shown in Table 4. Maximum condition factor was 0.95 in female population age class 0+; 0.77 in male population age class 3+; 0.765 in total population age class 3+ whereas minimum condition factor was 0.76 in female population age class 2+ and 3+; 0.74 in male population age class 1+; 0.73 in total population age class 1+. Between age and sex's condition factor relationship differences were in age class 1+ and 2+.

Table 4. Changing condition factor to age

	Condition Factor		
Age Class	Female	Male	Total
	mean ± SD (min-max)	mean ± SD (min-max)	mean ± SD (min-max)
0+	0.95 ± 0.22 (0.79 – 1.10)	0.76 ± 0.099 (0.7 – 0.89)	0.76 ± 0.18 (0.56 -1.10)
1+	0.79 ± 0.13 (0.53 – 1.22)	0.74 ± 0.81 * (0.50 – 1.31)	0.73 ± 7.67 (0.50 – 1.31)
2+	0.76 ± 0.14 (0.21 – 1.28)	0.76 ± 0.15 * (0.36 – 1.17)	0.76 ± 0.7 (0.21 – 1.28)
3+	0.76 ± 0.18 (0.56 – 0.98)	0.77 ± 0.86 (0.52 – 1.17)	0.765 ± 0.48 (0.52 – 1.17)

*The asterisk (*) indicates significant differences ($P<0.005$).

Months and condition factor relationship was shown in Table 5. In female population, minimum condition factor was 0.60 in November and maximum condition factor was 0.89 in April. In male population, minimum condition factor was 0.59 in November and maximum condition factor was 0.90 in July. In total population, minimum condition factor was 0.60 in November and maximum condition factor was 0.88 in April. There were significant differences female and male's condition factor in July, August, February, March, April, May, June ($P<0.005$).

Table 5. Changing condition factor to months

	Condition Factor		
Months	Female	Male	Total
	mean ± SD (min-max)	mean ± SD (min-max)	mean ± SD (min-max)
July 2013	0.86 ± 0.87 (0.77 – 0.98)	0.8 ± 0.84* (0.69 – 1.014)	0.77 ± 3.88 (0.51 – 1.014)
August 2013	0.74 ± 0.07 (0.66 – 0.81)	0.68 ± 0.13* (0.42 – 0.92)	0.69 ± 0.11 (0.42 – 0.92)
September 2013	0.68 ± 0.18 (0.21 – 0.91)	0.70 ± 0.079 (0.62 – 0.86)	0.68 ± 0.13 (0.21 – 0.91)
October 2013	0.69 ± 0.068 (0.63 – 0.84)	0.65 ± 0.058 (0.54 – 0.71)	0.67 ± 0.066 (0.54 – 0.84)
November 2013	0.60 ± 0.079 (0.55 – 0.83)	0.59 ± 0.052 (0.52 – 0.69)	0.6 ± 0.062 (0.52 – 0.83)
December 2013	0.79 ± 0.069 (0.75 – 0.89)	0.79 ± 0.082 (0.56 – 0.92)	0.71 ± 0.077 (0.56 – 0.92)

Table 5. Changing condition factor to months (continued)

	Condition Factor		
Months	Female	Male	Total
	mean ± SD (min-max)	mean ± SD (min-max)	mean ± SD (min-max)
January 2014	0.76 ± 0.073 (0.62 – 0.90)	0.72 ± 0.081 (0.60 – 0.87)	0.76 ± 0.08 (0.60 – 0.90)
February 2014	0.69 ± 0.11 (0.53 – 0.84)	0.72 ± 0.21* (0.36 – 1.17)	0.72 ± 0.19 (0.36 – 1.17)
March 2014	0.87 ± 0.15 (0.68 – 1.22)	0.85 ± 0.091* (0.74 – 1.07)	0.86 ± 0.13 (0.68 – 1.22)
April 2014	0.89 ± 0.17 (0.62 – 1.08)	0.88 ± 0.086* (0.69 – 1.02)	0.88 ± 0.12 (0.62 – 1.08)
June 2014	0.79 ± 0.109 (0.60 – 0.95)	0.79 ± 0.155* (0.57 – 1.31)	0.79 ± 0.134 (0.57 – 1.31)
July 2014	0.85 ± 0.69 (0.71 – 0.98)	0.90 ± 0.13 (0.69 – 1.17)	0.87 ± 0.102 (0.69 – 1.17)

*The asterisk (*) indicates significant differences (p<0.005)

3.2.4. Rational growth increase

The rational length increase were determined by using total length. Female population rational length increase values were 0.19 (in age class 0+), 0.17 (in age class 1+) and 0.15 (in age class 2+) whereas male population values were 0.24 (in age class 0+), 0.18 (in age class 1+) and 0.14 (in age class 2+). For total population rational length increase values were 0.2 (in age class 0+), 0.18 (in age class 1+) and 0.15 (in age class 2+) (Table 6).

Female population rational weight increase values were 0.4 (in age class 0+), 0.55 (in age class 1+) and 0.6 (in age class 2+) whereas male population values were 1.15 (in age class 0+), 0.7 (in age class 1+) and 0.55 (in age class 2+). For total population rational weight increase values were 0.71 (in age class 0+), 0.66 (in age class 1+) and 0.57 (in age class 2+) (Table 6).

Table 6. Relationship between age class and rational length and weight increase in *Pseudorasbora parva* population from Lake Mogan

Age Class	Female		Male		Total		Female		Male		Total	
	Total Length (mm)						Total Weight (g)					
	mean	OL[1]	mean	OL[1]	mean	OL[1]	mean	OW[2]	mean	OW[2]	mean	OW[2]
0+	49.5		47.7		49.1		1.16		0.71		0.9	
		0.19		0.24		0.2		0.4		1.15		0.71
1+	58.7		59		58.7		1.62		1.53		1.54	
		0.17		0.18		0.18		0.55		0.7		0.66
2+	68.8		69.7		69.3		2.51		2.6		2.56	
		0.15		0.14		0.15		0.6		0.55		0.57
3+	79.1		79.7		79.8		4		4.02		4.02	

[1]. Rational length, [2]. Rational weight

4. Discussion

The present study clearly demonstrates that the *Pseudorasbora parva*'s populations growth parameters. Five age classes (0+, 1+, 2+, 3+ and 4+) of *Pseudorasbora parva* population's were previously described by Witkowski (2011). In present study, based on the weights only four age classes were identified (except age class 4+). Significant differences between sex and age class, age class 1+ and 2+ were observed in terms of total lenght and weight (P<0.005). *P. parva* starts to spawn at age class 1+ and reach maximum fecundity rates at age class 1+ and 2+ (Witkowski, 2011). Soon as it reaches one year old, the growing process becomes much faster and since gonads are produced. Maximum lenght and weight would be achieved during this period of time.

The length-weight relationship is an indicator mainly related to the temperature changing in water, food ability and reproductive activity; while ''b'' value is affected by various factors such as sex, age, gonad maturity, habitat, season (Kırankaya, 2014). Hence, ''b'' value is an indication of growth structure. If ''b'' value is under 3, population growth is defined as negative allometric; If it is above 3, population growth is positive allometric; and if ''b'' value is 3, population growth is defined as isometric growth (Karataş, 2010). With reference to this, in present study total population was found as negative allometric growth; while female and male populations were found as isometric growth.

High condition factor values indicates good environmental condition whereas low condition factor values indicates bad environmental condition. The condition factor fluctuates due to food ability, health condition and maturity. Differences between condition factors were considered as indicative of various biological features such as fatness, and suitability of the environment (Kırankaya, 2014).

In this study, Fulton's condition factor was evaluated as not only age and population but also by month and population. In age classification, there were significant differences between female and male in age classes 1+ and 2+ (Table 4). Due to the change in the ovary weight, population's condition factors were found to have changed drastically in different months in female population's condition factors were changed a lot because of the change ovary weight. In male population, the change in the condition factor was much less compared to female's, since the testicular weight change was much less. Significant differences were found in July, August, from February to June. These months refer to the period of the beginning of the occurence of reproductive cells and the initiation of the spawning season. Another important factor is the active period of fish. For finding food refers to during these periods.

5. Conclusion

The present study provided new information on the population and growth parameters of the invasive species *Pseudorasbora parva* of Lake Mogan, Ankara, Turkey which would provide a valuable contribution to the biology of this species and create a basis for the conservation of resources. These parameters would be helpful in subsequent fishery research and management, especially in those concerning conservation and restoration programmes for invasive fishes.

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