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Research Article **Araştırma Makalesi**

Length-Weight Relationship and Condition Factor of the *Mastacembelus simack* (Bank & Solander, 1794) at Different Locations on the (Tigris and Murat Rivers) Türkiye

Mastacembelus simack (Banks & Solander, 1794) Türünün Farklı Lokasyonlardaki (Dicle ve Murat nehirleri) Boy-Ağırlık İlişkisi ve Kondisyon Faktörü

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Abstract: In this study, the length-weight relationship (LWR) and condition factor (CF) of Mesopotamian spiny eel *Mastacembelus simack* (Banks & Solander, 1794) caught from the Tigris River and Murat River basins between 2014 and 2016 were investigated. While the length of the fishes ranged between 24.00 and 67.40 cm for Tigris basin and 27.20 and 60.50 cm Murat basin, the weights changed between 31.70 and 585.30 g for Tigris basin and 38.20 and 385.00 g for Murat basin. It was determined positive allometric growth in individuals with a length of between 27.20 and 31.80 cm (b=3.54) in Murat Basin, 41.20 and 52.80 cm (b=3.27), and 53.70 and 67.40 cm (b=4.77) in Tigris Basin, while negative allometric growth (b<3) was determined in total all samples of both basins. The length-weight relationship was found as $W=0.005L^{2.73}$ ($R^2=0.94$) for Tigris and $W=0.005L^{2.75}$ ($R^2=0.97$) for Murat rivers. Average CF has the same value (CF=19) for Tigris and Murat rivers basin fish.

Keywords
- Mesopotamian spiny eel
- LWR
- CF
- Negative allometric

Özet: Bu çalışmada, 2014-2016 yılları arasında Dicle Nehri ve Murat Nehri havzalarından yakalanan Mezopotamya dikenli yılan balığı *Mastacembelus simack*'in (Banks & Solander, 1794) boy-ağırlık ilişkisi (LWR) ve kondisyon faktörü (CF) araştırılmıştır. İncelenen balıkların toplam boy ve ağırlıkları Dicle Havza'sında 24.00 ve 67.40 cm ile 31.70 ve 585.30 gr arasında, Murat Havzası'nda 27.20 ve 60.50 cm ile 38.20 ve 385.00 g arasında değişmektedir. Her iki havzadaki toplamda tüm örnekler için negatif allometrik büyüme (b<3) belirlenirken, Murat Nehri'nde boyu 27.20 ile 31.80 cm (b=3,54), Dicle Havzasında 41,20 ile 52,80 cm (b=3,27) ve 53,70 ile 67,40 cm (b=4.77) arasında olan bireylerde pozitif allometrik büyüme belirlenmiştir. Boy-ağırlık ilişkisi Dicle Havzası'nda $W=0.005L^{2.73}$ ($R^2=0.94$) ve Murat Nehri'nde $W=0.005L^{2.75}$ ($R^2=0.97$) olarak bulunmuştur. Dicle ve Murat nehri havzalarındaki balıklar, ortalama aynı CF değerlerine sahiptirler (CF=19).

Anahtar kelimeler
- Mezopotamya dikenli yılan balığı
- LWR
- CF
- Negatif allometrik

1. INTRODUCTION

Mastacembelus simack (Spiny eel)is a species from the family Mastacembelidae (Kottelat, 2022). It is an endemic freshwater fish species living in the Euphrates and Tigris rivers (Coad, 1996). Spiny eel is economically important and palatable as a table fish, and demand for fish almost always exceeds supply, especially in northern and eastern India where people love alive and less bony fish (Serajuddin, 2005). Similarly, spiny eel species of Mastacembelidae are also considered delicious, excellent food, and aquarium fish in the Asian subcontinent (Narejo et al., 2003). Additionally, it is used as a native aquarium fish in America, Europe, and Asian countries in terms of ornamental value (Sugunan et al., 2002; Tripathi, 2004; Grupta & Banerjee, 2014). It is also consumed as food in Türkiye and an important source of income for commercial fishing (Oymak et al., 2009). They

generally live in lotic and lentic systems with muddy and sandy bottoms where vegetation is plentiful and altitude is low (Froese & Pauly, 2023; Coad, 2021). Additionally, they hide in plants or are buried in the bottom mud to protect themselves during the day (Kara et al., 2014; Vreven & Teugels, 2005; Jalali et al., 2008). Mesopotamian spiny eel is distributed in Tigris, Euphrates, and Asi River systems (Dağlı & Erdemli, 2009; Geldiay & Balık, 2009). The Mesopotamian spiny eel was reported (Koyun et al.,2018; Koyun & Çelik, 2020) in Göynük Stream (Bingöl) from Murat River, in the Aksu, Merzimen, Ambar, Sinnep streams from Euphrates Basin (Kalaycı & Durmaz, 2022), in Başur, Zarova and Bağlıca streams and Rotan River (Siirt) from Tigris Basin, and in the Amber Stream (Diyarbakır) (Kaya et al., 2016).

The weight-length relationship (LWR) has been used in many fields for fish biology and fisheries management (Petrakis & Stergiou, 1995; Froese & Pauly, 2012) to calculate the production and biomass of a fish population (Giacalone et al., 2010). LWR is also useful in local and interregional, morphological, and life history comparisons of species and populations (Kara & Bayhan, 2008). The condition factor (CF) is also an effective parameter to assess the evolution of fish overweight status and to compare the general physiological state of the fish population during a seasonal cycle or basins with different ecological conditions (Lévêque, 2006). *a*, *b*, and CF values are valid parameters used to evaluate the dynamic characteristics and biomass of populations (Da Silva et al., 2020).

LWR and CF give information about the growth of the fish species. Therefore, they have great importance in fisheries evaluation studies (Jisr et al., 2018). The size of fish is representative of age, diet, and other physiological and environmental factors. Variability in size has important implications for various aspects of fisheries science and population dynamics (Erzini, 1994). In general, the fish's LWR is also useful for cross-regional comparisons of species' life history (Binohlan & Pauly, 1998; Stergiou & Moutopoulos, 2001).

Although there are many studies on the LWR and CF of different spiny eel species (e.g. *Macrognathus armatus*: Serajuddin, 2005; Narejo et al., 2003; Sarkar et al., 2013; Awas et al., 2020; Ponnuvel et al., 2022, *M. aculeatus:* Pathak & Mohd, 2015, *M. pancalus*: Pathak et al., 2013; Hussain, 2013; Abujam & Biswas, 2016; Sarkar et al., 2013, *M. siamensis* and *M. aral*: Ponnuvel et al., 2022) in many Asian countries. However, studies on *M. simack*, which is an endemic species for Tigris and Euphrates basins, are limited. Studies on the age structure and growth properties of *M. mastacembelus* in southern Iran (Pazira et al., 2005). Further, Oymak et al. (2009) reported preliminary information on LWR and the growth of *M. mastacembelus* from Türkiye. The age and growth of *M. mastacembelus*, from south-eastern Anatolia were studied by Gümüş et al. (2010). Then, Gerami et al. (2013) reported on LWR of *M. mastacembelus* from Cholvar River, western Iran, and some biological properties including LWR of *M. mastacembelus* were reported from the upper Euphrates River Basin in Türkiye by Çoban et al. (2021). Therefore, this study aimed to provide basic data and updated information about the LWR and condition factor for *M. simack* in two different water basins (Tigris and Murat rivers). Obtained results will contribute to the protection of natural *M. simack* stocks in these regions.

2. MATERIALS and METHODS

2.1. Sample collection

Two sampling sites were selected, located on two different rivers (Tigris and Murat rivers) in the same geographical region and characterized by different environmental conditions. The station in Tigris River Basin was selected in Bismil/Diyarbakır (37°50′02.94″N, 40°41′52.10″E) and Murat River Basin was selected in Genç/Bingöl (38°49'20.42"N, 40°40'16.94"E) from May 2014 to July 2016. 4 samplings from Murat River and 6 samplings from Tigris River Sampling were based on annual sampling. 6 samples were taken from the Tigris River (May and September 2014, 2015, and 2016) and 4 (December 2014, June and October 2015, and June 2016) from the Murat River. All fish samples were caught by gill net, bag net, and fish trap during the sampling period. Fish samples were transported to the laboratory and necessary measurements were made immediately.

2.2. Length-weight relationship (LWR) and Condition factor (CF)

The LWR of Mesopotamian spiny eel was analyzed by measuring the length and weight of fish specimens collected from the sampling area. The total length (TL) of each fish specimen was measured to a sensitivity of 0.1 cm. The total weight (TW) was taken using a digital balance with a

precision of 0.01 g. The statistical relationship between these parameters of the fish was established by using the equation of $TW=a\times TL^{b}$. In this equation; TW is the total weight of specimen (g), TL is the total length (cm), a is the intercept and b is the slope of the relationship (Bagenal & Tesch, 1978). In other words, TW = the total weight of fish (g), TL = the total length (cm), a = the coefficient related to body form, and b = an exponent indicating isometric growth expressing the relationship between length-weight.

Fulton's CF is used to reveal the condition of the length and weight of fish. It is based on the assumption that heavier fish of a given length are in better condition (Sheikh & Ahmed, 2018). Fulton's CF was calculated for all individuals by the following equation (Fulton, 1911):

$CF = 100TW/TL^{3}$

Preliminary statistics (mean, standard deviation, minimum and maximum values) were computed for TW, TL, and CF.

2.3. Statistical analysis

The relationships among the variables were identified using the regression analysis (Spearman Rank Correlation). The observed differences were evaluated statistically using STATISTICA software and t-test, independent, by groups. Statistical differences in *b* value were tested among the locations using a one-way analysis of variance (ANOVA) test with $p<0.05$.

3. RESULTS and DISCUSSION

The length-weight relationship of *M. simack* collected from Tigris and Murat rivers was analyzed in this study. 62 were collected from Tigris/Bismil, and 24 were collected from Murat/Genç of the 86 specimens,. The total length of Murat River ranged from 27.20-60.50 cm with a mean of 38.80 cm. The total length of Tigris River ranged from 24.00-67.40 cm with a mean of 42.00 cm. The total weight values of Murat and Tigris rivers ranged from 38.20-385.00 g (mean=123.99 g) and 31.70-585.30 g (mean=156.07), respectively (Table 1).

The calculated linear regression showed the differences between the slopes of the LWR in *M. simack* between the location of Tigris and Murat rivers. The significance of the LWR and CF of *M. simack* were tested among these locations using ANOVA, and the values for each location were tested by Fisher's LSD (Least Significant Difference) test to verify its significance level in length and weight.

The difference between the two locations was statistically insignificant in terms of total length ($p=0.15$) and weight ($p=0.18$) ($p>0.05$). The most dominant length group in Tigris Basin was between 31.00 and 40.90 cm with an average value of 37.90 cm (n=25). Every length group number in Murat Basin was equal with 8 samples and the total sample number was 24 (Table 1). Therefore, every length group was at the same dominant rate. Some studies reveal the LWR of individuals belonging to the Mesopotamian spiny eels (Table 2).

Table 1. Mean length-weight relationship parameters of *M. simack* in Tigris River and Murat River ($p<0.05$)

n	Mean TL±SD (cm)	L(cm) (Min-Max)	Mean TW±SD (g)	W (g) (Min-Max)	a	b	R^2	CF±SD	CF (Min-Max)	LWR	Growth (t-test)
Murat/Genç											
8	29.80±1.44	27.20-31.80	53.57±9.31	38.2-66.8	0.0003	3.54	0.94	0.20±0.10	0.19-0.22	$W=0.0003L^{3.54}$	A(+)
8	36.83±3.26	32.40-40.90	91.18±20.96	57.16-121.8	0.03	2.18	0.61	0.18±0.03	0.14-0.24	$W=0.03L^{2.18}$	A(-)
8	39.70±1.16	42.10-60.50	227.23±98.22	140.1-385.00	0.002	2.96	0.96	0.19±0.03	0.15±0.20	$W=0.002L^{2.96}$	I
24	**38.80±9.45**	**27.20-60.50**	**123.99±96.33**	**38.20-385.00**	**0.005**	**2.75**	**0.97**	**0.19±0.03**	**0.14-0.27**	$\mathbf{W=0.005L^{2.75}}$	**A(-)**
Tigris/Bismil											
8	27.81±2.46	24.00-30.00	46.48±11.94	31.7-62.8	0.02	2.39	0.74	0.21±0.03	0.17-0.25	$W=0.0164L^{2.39}$	A(-)
25	37.90±2.64	31.00-40.90	105.51±22.12	65.2-152.4	0.06	2.06	0.49	0.19±0.03	0.14-0.27	$W=0.057L^{2.02}$	A(-)
24	47.39±3.54	41.20-52.80	201.89±51.93	118.50-282.2	0.0007	3.27	0.80	0.19±0.03	0.15-0.25	$W=0.0007L^{3.27}$	A(+)
5	59.28±5.62	53.70-67.40	364.26±167.83	217.00-585.30	0.0000001	4.77	0.97	0.17±0.03	0.14-0.21	$W=1E\text{-}06L^{4.77}$	A(+)
62	**42.00±8.91**	**24.00-67.40**	**156.07±100.37**	**31.70-585.30**	**0.005**	**2.75**	**0.94**	**0.19±0.03**	**0.14-0.27**	$\mathbf{W=0.005L^{2.75}}$	**A(-)**

Çoban et al. (2021) identified that Mesopotamian spiny eel was in the 59-64 cm lengths and 13-1131 g weights group in Euphrates River, Türkiye. Wahab (2019) reported as 27-63 cm for lengths and 48-549 g weights in 62 individuals of *M. mastacembelus* in Iraq. Pazira et al. (2005) found the maximum total lengths for *M. mastacembelus* were 432 mm in Southern Iran. Oymak et al. (2009) indicated that total lengths and weights ranged from 7.0 to 85.0 cm and from 6 to 1100 g, respectively in Atatürk Dam Lake, South-eastern Türkiye. It was reported that it reached a length of 1 m and a weight of 1 kg in Iraq by Coad (2010). We found that there was no statistically significant difference between the locations in terms of both length ($p=0.15$, $p>0.005$) and weight ($p=0.18$, $p>0.05$).

LWR interprets the effect of different factors such as habitat type and feeding habits on fish growth (Agumassie, 2018). Ricker (1975) stated that the live weight of the fish is affected by different factors such as the season, stomach content, spawning status, etc. The paired sample Student t-test of was used to compare *b* to 3. The value of b is 3 when fish growth is unchanged (b=3), indicating isometric growth and is a good indicator of the type of growth (Wootton, 1990). When the b value is greater than 3 ($b>3$, $p<0.05$), it means that the weight of a fish increases as it grows in length, it shows positive allometric growth, and when it is less than 3 ($b<3$, $p>0.05$), its weight decreases as the body length increases, and when it looks 'slimer', it shows negative allometric growth (Richer, 1975; Yılmaz et al., 2012).

In this study, length groups were formed to determine which group of individuals showed the highest growth rate. Length groups were determined based on b "high b values". *b* values are different from 3 in both Murat (2.75) and Tigris rivers (2.73). The length-weight relation (LWR) of *M. simack was* $W=0.005L^{2.72}$ for Tigris/Bismil and $W=0.005L^{2.75}$ for Murat/Genç with negative allometry (Student's t-test; $p < 0.05$) (Table 4). Pazira et al. (2005) found that the growth of *M. mastacembelus* was negative allometric growth (*b*=2.54 males; *b*=2.73 females). Oymak et. al. (2009) found *b*<3 for *M. mastacembelus* had negative allometry from Atatürk Dam Lake in Türkiye (Oymak et al, 2009). Gümüş et al. (2010) referred that *b* was 2.84 (negative allometry) for *M. mastacembelus* from Southern Türkiye. Similarly, *b* was 2.68 from Cholvar River in the Karun River, Iran (Gerami et al., 2014). In addition, when the values of different length groups were compared, it was determined that individuals with a length of between 27.20 and 31.80 cm showed positive allometry (b=3.54) in the Murat Basin. Individuals with a length of between 41.20 and 52.80 cm (b=3.27), and 53.70 and 67.40 cm (b=4.77) showed positive allometry in Tigris Basin. Negative allometry indicates that the fish species expend more energy on axial growth than biomass (Liu et al., 2016) and helps them escape predators and forage (Weitzman & Palmer, 2003). To appreciate the fish's well-being, *b* is compared to 3. If *b* is not significantly different from 3, the species shows a good adaptation to the dominant ecologic condition of the habitat. If it is not, there is less adaptation (Baijot et al., 1994).

The coefficient of determination (R^2) values explained the proper fit of the growth model (Datta et al., 2013). R^2 for *M. simack* was reported as 0.97 in Tigris River (Iran) by Esmaeili et al. (2014) and 0.98 in Atatürk Dam Lake (Turkey) by Gümüş et al. (2010). R^2 was 0.94 in Tigris Basin and 0.97 in Murat Basin (Figure 1, Table 1). Combined genders and the use of a small sample size may affect R^2 values (Esmaeili et al., 2014). It is assumed that males gain more weight as they grow taller, indicating better well-being. It was observed that the groups with the longest length-weight range had the highest R^2 value in both Murat and Tigris Basin samples. The highest R^2 value was between 38.60 and 40.90 cm in length, 140.1 and 385.00 g weight ranges ($R^2=0.96$) in Murat Basin. 53.70-67.40 cm length and 217.00-585.00 g weight ranges had the highest R^2value ($R^2=0.97$) in Tigris Basin (Table 1).

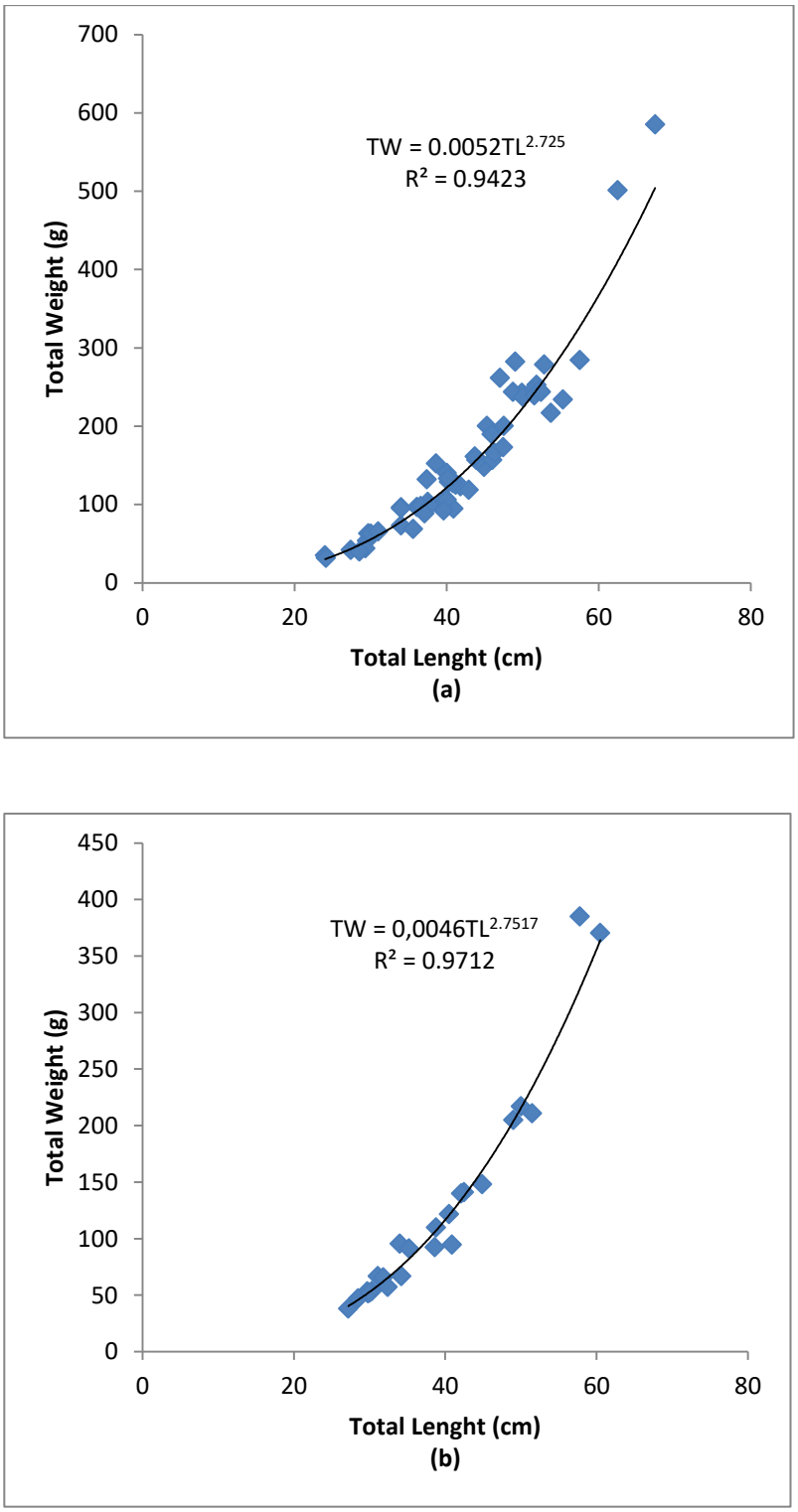

Figure 1. The total length-weight relationship of *M. simack* in Tigris/Bismil (a), Murat/Genç (b)

Table 2. Comparison of growth parameters of the spiny eels reported by different studies

Locations	Species	L (min-max)	W (min-max)	a	b	R^2	CF (min-max)	Authors
Helleh and Dalaky rivers, Iran	*M. mastacembelus*	0.42-43.20	2.6-201.90	-	-	-	0.16-0.46	Pazira et al., 2005
Atatürk Dam Lake, Euphrates River	*M. mastacembelus*	7.00-80.00	6.00-1100.00	-	-	-	-	Oymak et al., 2009
Atatürk Dam Lake, Euphrates River	*M. mastacembelus*	14.40-76.90	6.00-950.00	0.004	2.84	0.98	-	Gümüş et al., 2010
Cholvar River, Iran	*M. mastacembelus*	19.80-46.50	20.07-210.01	2E-05	2.68	0.97	-	Gerami et al., 2013
Keban Dam Lake, Euphrates River	*M. mastacembelus*	14.20-81.80	13.20-1131.10	0.006	2.73	0.97	0.14-0.49	Çoban et al., 2021
Mymensingh, Bangladesh	*M. armatus*	14.80-47.50	8.00-139.40	-	-	0.99	0.80-1.31	Narejo et al., 2003
Ganges River, India	*Macrognathus aculeatus*	1.13-1.31	-	-1.28	2.02	0.38	-	Pathak and Mohd, 2015
Godavari River, India	*Macrognathus aculeatus*	1.16-1.40	-	-3.16	3.53	0.88	-	Pathak and Mohd, 2015
Mahanadi River, India	*Macrognathus aculeatus*	1.24-1.44	-	-3.14	3.52	0.88	-	Pathak and Mohd, 2015
Gomti River, India	*Macrognathus pancalus*	10.10-18.50	-	-2.61	3.17	0.88	-	Pathak et al., 2013

While the CF was ranged from 0.14 to 0.27 (average 0.19) in Tigris Basin, the CF varied from 0.14 to 0.25 (average 0.19) in Murat Basin. When the mean values were examined, it was determined that both basins had an equal condition for Mesopotamian spiny eel and there was no statistical difference between the locations ($p=0.47$, $p>0.05$).

Total a, b, $R^{2,}$ and CF of the Mesopotamian spiny eel had no significant difference in both Murat and Tigris basins. However, there were differences between the length groups for these parameters in both basins. It is known that LWR differs depending on many environmental factors such as different habitats, physicochemical properties of water, pollution status, amount of food in the environment, season, and reproduction in the same species. Therefore, there may be great differences between parameters related to the same species (Avşar, 2005). In this study, even if it is the same species, we can say that these differences between the length groups, even if it is the same species are due to the different environmental conditions of the two different river basins.

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CONFLICTS of INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in the paper.

ETHICAL STATEMENT

All fish captures and tagging were conducted under Bingöl University Animal Experiments Local Ethics Committee Directive **(2015/02).**

DATA AVAILABILITY STATEMENT

Data used in this study are available from the corresponding author upon reasonable request.

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