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Araştırma Makalesi

Bayat Göleti (Ankara, Türkiye)'nde Yaşayan İsrail Sazanı (*Carassius gibelio*, Bloch 1782) Üzerine Morfometrik Bir Değerlendirme: Boy-Ağırlık İlişkisi, Kondisyon Faktörü ve Boy-Boy Dönüşümleri[a]

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ÖZ

Bu çalışma, Ankara ilinde yer alan lentik bir iç su kütlesi olan Bayat Göleti'nde yaşayan istilacı sazan türü *Carassius gibelio* (Bloch 1782)'nun biyometrik özelliklerini araştırmayı amaçlamaktadır. 2017 yılı ilkbahar döneminde toplam 45 birey örneklenmiş ve boy–ağırlık ilişkisi (LWR), kondisyon faktörü (K) ve boy–boy dönüşüm ilişkileri (LLRs) analiz edilmiştir. Elde edilen LWR denklemi $W = 0.011 \cdot TL^{3.214}$ ($R^2 = 0.973$) olup, *b* katsayısı 3'ten istatistiksel olarak anlamlı düzeyde farklı bulunmuştur ($p < 0.05$), bu da pozitif allometrik büyümeyi işaret etmektedir. *b* değeri için %95 güven aralığı 3.051–3.377 olarak hesaplanmıştır. Ortalama kondisyon faktörü 2.27 (±0.26) olup bireylerin genel fizyolojik durumunun iyi olduğunu göstermektedir. Bayat Göleti verileri, Türkiye ve çevresindeki 30'dan fazla tatlı su habitatında yapılmış önceki çalışmalarla karşılaştırıldığında, *b* ve K değerlerinin geniş bir aralıkta değiştiği ve türün çevresel koşullara karşı yüksek fenotipik plastisite gösterdiği ortaya konmuştur.

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Ayrıca, total, fork ve standard uzunluk ölçümleri arasında güçlü doğrusal ilişkiler ($R^2 > 0.96$) bulunmuştur. Elde edilen bu bulgular, iç sularda *C. gibelio* popülasyonlarının izlenmesi ve istilacı türlerin ekosistem yönetimi açısından önemli bir temel veri sağlamaktadır.

Anahtar Kelimeler: İsrail sazanı, biyometrik analiz, morfometri, büyüme tipi, tatlısu ekosistemi.

Research Article

Morphometric Assessment of Prussian Carp (*Carassius gibelio*, Bloch, 1782) inhabiting Bayat Pond (Ankara, Türkiye): Length-Weight Relationship, Condition Factor, and Length–Length Conversions

ABSTRACT

This study aims to investigate the biometric characteristics of the invasive cyprinid *Carassius gibelio* (Prussian carp) inhabiting Bayat Pond, a lentic freshwater body located in Ankara Province, Turkey. A total of 45 individuals were sampled during the spring of 2017 and analyzed for length–weight relationships (LWR), condition factor (K), and length–length relationships (LLRs). The LWR equation was calculated as $W = 0.011 \cdot TL^{3.214}$ ($R^2 = 0.973$), with the exponent *b* significantly differing from 3 ($p < 0.05$), indicating positive allometric growth. The 95 % confidence interval for the growth exponent lay between 3.051 and 3.377. An average condition factor of 2.27 ± 0.26 points to a population in generally sound health. When set against more than thirty published data sets from both still- and running-water habitats, the Bayat Pond *b* and *K* values fall comfortably within the broad spectrum reported for the species—evidence of its pronounced phenotypic flexibility and capacity to adjust to local conditions. Strong linear fits among total, fork and standard lengths (all $R^2 > 0.96$) further enable robust conversion between length metrics. Taken together, these results supply a valuable baseline for tracking the ecology of *C. gibelio* in Turkish inland waters and support informed management of this invasive cyprinid.

Keywords: Prussian carp, biometric analysis, morphometry, growth pattern, freshwater ecosystem.

INTRODUCTION

Understanding how fish allocate energy to growth and body condition has long been a mainstay of fisheries science. Three biometric tools lie at the heart of that effort: length-weight relationships (LWR), Fulton's condition factor (CF), and length-length conversions (LLRs). Each metric answers a slightly different question. LWRs, noted by Froese (2006), Le Cren (1951), and Lizama & Ambrosio (2002), trace how mass scales with size and, by way of the exponent *b*, reveal whether growth is isometric or allometric in nature (Bagenal & Tesch 1978). Condition factor, first proposed by Fulton and later refined by Bolger & Connolly (1989), reflects how "well-fed" or stressed fish are under prevailing habitat conditions; when tracked over seasons, CF can even double as a rough index of ecosystem productivity (Blackwell et al. 2000). Finally, LLRs stitch together datasets that rely on different length measures, allowing researchers to compare apples to apples across studies (Anderson & Neumann 1996). In aquaculture settings, the same trio of metrics guides broodstock selection, stocking density, and harvest scheduling (King 2007).

Such analyses become especially pertinent in reservoirs, which (owing to hydrological alteration, habitat patchiness, and chronic human pressure) often behave quite differently from natural lakes. These man-made systems can also serve as way-stations for invaders. One frequently cited example is *Carassius gibelio* (Prussian carp), an East-Asian cyprinid that now spans Eurasia (Kottelat & Freyhof 2007; Gozlan et al. 2010). Its success hinges on a remarkable ecological toolkit: tolerance of low oxygen, high fecundity (including gynogenetic reproduction), and a growth strategy resilient to fluctuating conditions (Tarkan et al. 2012; Ribeiro et al. 2008). In waters lacking effective predators or competitors, *C. gibelio* often ascends the trophic ladder, reshaping community structure and depressing native biodiversity (Gozlan et al. 2010; Copp et al. 2005).

Given these concerns, regular biometric monitoring is more than an academic exercise; it is a management necessity. By establishing robust LWRs, CF baselines, and LLR equations for reservoir populations, managers gain a first-look diagnostic of invader performance and a yardstick for future interventions. With that aim in mind, the present study investigates length–weight dynamics, condition factor, and length conversions for *C. gibelio* in Bayat Pond, with an eye toward informing fisheries practice, optimizing aquaculture decisions, and sharpening invasive-species control in lentic freshwater systems.

MATERIAL AND METHODS

This investigation focused on *Carassius gibelio* collected from Bayat Pond, a lentic freshwater body situated in Ankara Province, Türkiye. The pond is a key local asset that supports both irrigation and small-scale, artisanal fisheries (Yazıcı & Saylar 2022). Field sampling was conducted in spring 2017. With help from local fishers, 45 specimens were captured using traditional gill-nets.

After capture, the fish were transferred to the laboratory for morphometric analysis. Total length (TL), fork length (FL) and standard length (SL) were measured to the nearest 0.01 cm. Body mass (W) was determined to the nearest 0.1 g on a precision electronic balance.

To assess the length–weight relationship (LWR), the data were fitted to the conventional allometric equation described by Bagenal and Tesch (1978) and later refined by Froese (2006):

$$W = a \times L^b$$

In this equation, W refers to the body weight of the fish in grams, while L denotes its total length in centimeters. The parameter a represents the intercept of the regression model, and b corresponds to the slope, which characterizes the nature of the growth—indicating whether it follows an isometric pattern ($b \approx 3$) or deviates toward allometric growth ($b \neq 3$).

For parameter estimation, the power-function model was log-transformed, converting the nonlinear equation to a linear form and allowing coefficients a and b to be obtained through ordinary least-squares regression. Afterward, a Student's t-test, applied as described by Zar (1999), was used to judge whether the resulting growth exponent matched the isometric reference value ($b = 3$) or instead reflected allometric growth ($b \neq 3$).

The physiological status of each fish was assessed with Fulton's condition factor, K, calculated as $K = (W / L^3) \times 100$, where W is body mass (g) and L is total length (cm) (Ricker 1975). This metric provides a straightforward gauge of nutritional condition across different environmental settings.

In addition, separate linear regressions were fitted for each pair of length measurements (total length (TL), fork length (FL) and standard length (SL))to enable direct comparison with regional and international datasets (Zar 1999). All analyses were executed in the RStudio environment.

RESULTS AND DISCUSSION

The descriptive statistics for the *Carassius gibelio* individuals sampled from Bayat Pond was given Table 1.The specimens had an average total length (TL) of 29.6 cm, fork length (FL) of 27.3 cm, and standard length (SL) of 24.3 cm. Their body weights ranged from 160 g to 580 g, with a calculated mean of 325.7 g.

Table 1. Descriptive statistics of length and weight of *C. gibelio* from Bayat Pond

	N	Mean	Min	Max	SE	SD
Weight (g)	45	325.7	160.0	580.0	14.56	97.8
Total Length (TL, cm)	45	29.6	18.5	40.0	0.87	5.81
Fork Length (FL, cm)	45	27.3	17.0	36.0	0.81	5.42
Standard Length (SL, cm)	45	24.6	15.0	34.0	0.75	5.05

The relationship between total length and body weight in *Carassius gibelio* from Bayat Pond was described by the equation $W = 0.011 \times TL^{3.214}$. The model showed a strong correlation, with a coefficient of determination (R^2) of 0.973. The growth exponent b was calculated as 3.214, which was found to differ significantly from the isometric value of 3 based on the results of a Student's t-test ($P < 0.05$). This deviation indicates that the population demonstrates positive allometric growth. The 95% confidence interval for the b coefficient ranged from 3.051 to 3.377.

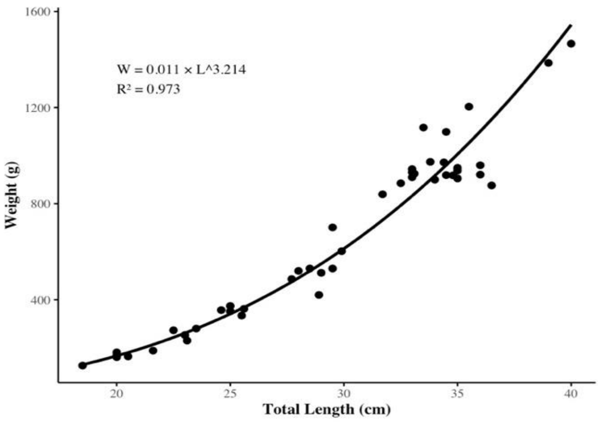

Figure 1. The length-weight relationship of *C. gibelio*.

Table 2. LWR: Summary of Previous Studies on *C. gibelio* in the Literature.

Reference	Habitat	a	b	r^2
Tarkan et al. 2006	İznik Lake	0.0084	3.25	0.989
Tarkan et al. 2006	Ömerli Dam	0.0099	3.18	0.991
Bostancı et al. 2007b	Bafra Balık Lake	0.0265	2.978	0.97
Bostancı et al. 2007a	Eğirdir Lake	0.0151	3.177	0.98
Sarı et al. 2008	Buldan Dam	0.031	2.87	0.985
İnnal 2012	Aksu River-Estuary	0.0138	3.114	0.976
Emiroğlu et al. 2012	Uluabat Lake	0.0349	3.0039	0.99
Bulut et al. 2013	Seyitler Reservoir	0.0274	2.9382	0.813
Yazıcıoğlu et al. 2013	Ladik Lake	0.0168	3.149	0.988
Ergüden 2015	Seyhan River	0.0673	2.571	0.927
İlhan and Sarı 2015	Marmara Lake	0.0173	2.974	0.976
Saç and Okgerman 2015	Büyükçekmece Lake	0.015	3.134	0.996
Stavrescu-Bedivan et al. 2015	Cişmigiu Lake	0.0055	3.6303	0.913
Sungur Birecikligil et al. 2016	Kızılırmak Basin	0.023	2.856	0.85
Hajiradkouchak et al. 2016	Golestan Lake	0.021	2.92	0.99
Hajiradkouchak et al. 2016	Voshmgir Lake	0.027	2.79	0.98
Fazli et al. 2018	Azad Lake	3e-06	3.3537	0.99
İnnal et al. 2019	Onaç Stream	0.0097	3.187	0.99
Reis et al. 2019	Sakarya River	0.0264	2.87	0.97
İlhan et al. 2020	Marmara Lake	0.018	2.965	0.986
Ağdamar and Gaygusuz 2021	Gökçeada Reservoir	0.023	3.129	0.93
Dereli et al. 2021	Demirköprü Reservoir	0.01	3.12	0.97
Baki et al. 2022	Bafra Balık Lake	0.0145	3.0347	0.96
Apaydın Yağcı et al. 2022	Eğirdir Lake	0.0108	3.1711	0.9793
Çiçek et al. 2022	Aras Basin	0.009	3.259	0.998
Çiçek et al. 2022	Asi Basin	0.014	3.07	0.863
Çiçek et al. 2022	Batı Akdeniz Basin	0.016	3.034	0.99
Çiçek et al. 2022	Çoruh Basin	0.023	2.83	0.978
Çiçek et al. 2022	Doğu Akdeniz Basin	0.011	3.156	0.998
Çiçek et al. 2022	Fırat Basin	0.007	3.319	0.998
Çiçek et al. 2022	Konya Basin	0.017	2.982	0.981
Çiçek et al. 2022	Seyhan Basin	0.009	3.171	0.949
Şimşek and Kale 2022	Asi River	0.0138	3.08	0.9606
Yalçın Özdilek and Partal 2022	Karamenderes Stream	0.0079	3.255	0.9898
This Study	Bayat Pond	0.011	3.214	0.973

The growth exponent (b) recorded for *Carassius gibelio* shows striking variation from one water body to another (Table 2). Reported figures range from just 2.571 in the Seyhan River (Ergüden 2015) to 3.6303 in Romania's Cişmigiu Lake (Stavrescu-Bedivan et al. 2015), a span that highlights the carp's marked phenotypic flexibility.

Many field surveys describe negative allometric growth ($b < 3$), where fish increase in length more quickly than in weight and develop a comparatively slender profile. Examples include the Seyhan River population ($b = 2.571$; Ergüden 2015) and Buldan Dam ($b = 2.87$; Sarı et al. 2008). Similar values have been noted in the Sakarya River ($b = 2.87$; Reis et al. 2019) and the Seyitler Reservoir ($b = 2.9382$; Bulut et al. 2013). Further evidence comes from the Kızılırmak Basin ($b = 2.856$; Sungur Birecikligil et al. 2016) and the Çoruh Basin, where Çiçek et al. (2022) logged a value of 2.83.

Conversely, several studies document positive allometry (*b* > 3), indicating that mass accrues more rapidly than length, yielding a deeper-bodied fish. Yazıcıoğlu et al. (2013) reported a *b* of 3.149 in Ladik Lake, whereas Fazli et al. (2018) recorded 3.3537 in Azad Lake. Comparable exponents have been published for Büyükçekmece Lake (*b* = 3.134; Saç and Okgerman 2015) and the Gökçeada Reservoir (*b* = 3.129; Ağdamar and Gaygusuz 2021). Additional examples include Onaç Stream (*b* = 3.187; İnnal et al. 2019) and several basins surveyed by Çiçek et al. (2022): Karamenderes (*b* = 3.255), Aras (*b* = 3.259), Eastern Mediterranean (*b* = 3.156), and Euphrates (*b* = 3.319). The most extreme value published to date—3.6303 in Cişmigiu Lake (Stavrescu-Bedivan et al. 2015)—illustrates how rapidly weight can accumulate when conditions are especially favourable.

On the other hand, certain populations of *Carassius gibelio* exhibit isometric growth patterns, where the increase in body weight corresponds proportionally with an increase in body length (i.e., b ≈ 3). For example, Emiroğlu et al. (2012) reported a b value of 3.0039 in Uluabat Lake, indicating isometric growth. Similarly, Şimşek and Kale (2022) observed a comparable value (b = 3.08) in the Asi River. Additional findings consistent with isometric growth were recorded by Çiçek et al. (2022) in several freshwater systems including the Asi Basin (b = 3.070), Batı Akdeniz Basin (b = 3.034), and Konya Basin (b = 2.982). A comparable pattern was also identified in the Seyhan Basin, where the reported b value was 3.171 (Çiçek et al. 2022).

A exponent (b) of 3.214 was obtained for the Bayat Pond population, pointing to a positively allometric growth pattern. Such a result implies that these fish thrive under favourable conditions (ample nutrition, limited competition, and well-structured habitat) that encourage proportionally greater weight gain relative to length. The growth trend recorded at Bayat Pond mirrors patterns reported for other still-water populations that also display positive allometry. Taken together, the broad spectrum of *b* values documented in different settings highlights the remarkable ecological elasticity of *C. gibelio*. This flexibility enables the species to adjust to a wide array of environmental circumstances an attribute that likely underpins its invasive success in many freshwater systems.

The average condition factor (*K*) for *Carassius gibelio* in Bayat Pond was 2.27 ± 0.26, a figure that points to good overall health and a well-filled body profile in the sampled fish.

Table 3. Summary of Condition Factor (K) Values for *C. gibelio* in the Literature

Reference	Habitat	Condition Factor (K)
Balık et al. 2004	Eğirdir Lake	2.498
Bostancı et al. 2007b	Bafra Balık Lake	2.494
Bostancı et al. 2007a	Eğirdir Lake	2.525
İnnal 2012	Aksu River	1.96
Bulut et al. 2013	Seyitler Reservoir	2.276
Yazıcıoğlu et al. 2013	Ladik Lake	2.676
Saç and Okgerman 2015	Büyükçekmece Lake	2.26
Stavrescu-Bedivan et al. 2015	Cişmigiu Lake	1.62
Sungur Birecikligil et al. 2016	Kızılırmak Basin	1.46
Fazli et al. 2018	Azad Dam	1.68
Ağdamar and Gaygusuz 2021	Gökçeada Reservoir	3.13
Baki et al. 2022	Bafra Balık Lake	1.65
Şimşek and Kale 2022	Asi River	1.759
Yalçın Özdilek and Partal 2022	Karamenderes Stream	1.55
This Study	Bayat Pond	2.27

The average condition factor (*K*) for *C. gibelio* in Bayat Pond was 2.27, a value that closely mirrors those reported from other Turkish reservoirs and lakes. Ladik Lake (2.676; Yazıcıoğlu et al. 2013), Seyitler Reservoir (2.276; Bulut et al. 2013), Büyükçekmece Lake (2.26; Saç and Okgerman 2015), Eğirdir Lake (2.498; Balık et al. 2004) and Bafra Balık Lake (2.494; Bostancı et al. 2007) all fall within the same general range, suggesting the Bayat population is in sound physiological condition.

Condition factor, however, can swing widely in response to habitat quality. At the lower end of the spectrum, Sungur Birecikligil et al. (2016) reported a *K* of 1.46 in the Kızılırmak Basin, whereas Ağdamar and Gaygusuz (2021) observed a high of 3.13 in the Gökçeada Reservoir. Such divergence underscores the carp's capacity to adjust to shifting food supply, habitat complexity, and contamination levels, as well as to intrinsic cycles such as reproduction.

In practice, then, *K* serves both as a quick check on individual health and as a broader gauge of habitat quality. The mid-range value recorded for Bayat Pond points to relatively favourable environmental conditions and a degree of ecological stability, factors that likely underpin the carp's ongoing success in this reservoir.

Length–length relationships (TL–SL, TL–FL, and FL–SL) were quantified via linear regression, and the resulting equations together with their coefficients of determination are presented in Table 4.

Table 4. Length transformations of *C. gibelio* population in Bayat Pond.

Equation	a	b	r^2
TL = a + b·FL	0.955	1.052	0.962
TL = a + b·SL	1.495	1.143	0.989
FL = a + b·SL	1.308	1.055	0.967

The tightest association emerged between total length and standard length ($R^2 = 0.989$; Fig. 2), whereas the total-length versus fork-length pairing yielded the weakest fit ($R^2 = 0.962$; Fig. 3). Even so, fork length and standard length were still closely linked ($R^2 = 0.967$; Fig. 4), underscoring that all three length metrics remain highly consistent with one another.

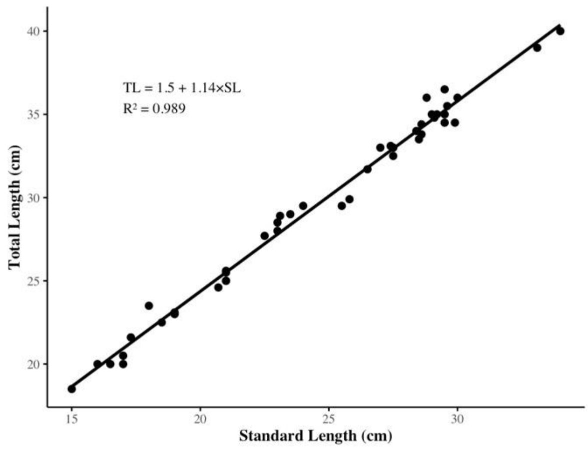

Figure 2. Linear relationship between total length (TL) and standard length (SL) in *Carassius gibelio* from Bayat Pond.

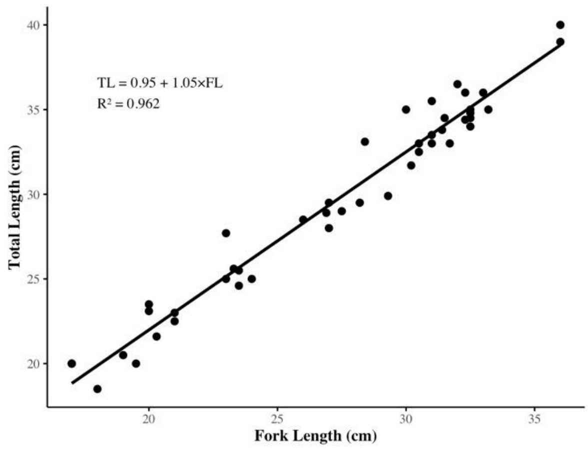

Figure 3. Linear relationship between total length (TL) and fork length (FL) in *Carassius gibelio* from Bayat Pond.

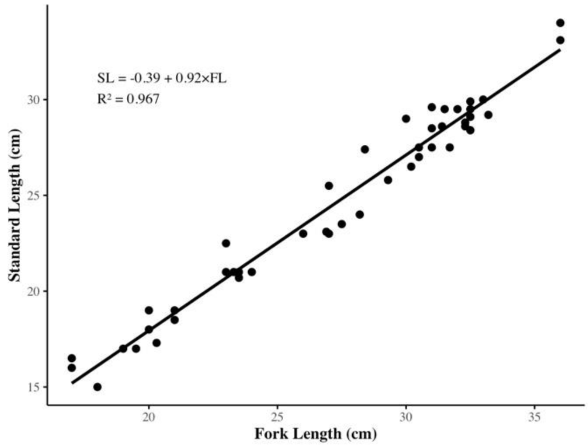

Figure 4. Linear relationship between fork length (FL) and standard length (SL) in *Carassius gibelio* from Bayat Pond.

Length-length relationships (LLRs) underpin comparative growth research, stock assessments, and the conversion of one length metric to another in fisheries science (Froese 2006). In our data set, every pairing of length measurements for *Carassius gibelio* from Bayat Pond produced a strong linear fit (all $r^2 > 0.96$). The tightest association occurred between total length (TL) and standard length (SL) ($r^2 = 0.989$), echoing the high correlations previously documented for Turkish populations in Bafra Fish Lake and Eğirdir Lake (Bostancı et al. 2007a, b). Such consistently high coefficients point to uniform body proportions across habitats. By contrast, the TL–fork-length (FL) regression was marginally weaker ($r^2 = 0.962$), a result that may reflect the greater variability typically seen in the forked-tail region—a pattern also noted for Büyükçekmece Lake fish by Saç and Okgerman (2015). Collectively, these robust correlations signal morphometric stability within the species and yield dependable conversion equations, tools that are indispensable for ecological comparisons and effective fisheries management.

CONCLUSION

The present analysis confirms that *Carassius gibelio* in Bayat Pond grows according to a positively allometric pattern. Nonetheless, the species is known to display a broad spectrum of growth modes (negative allometry, positive allometry, or near-isometry) depending on habitat characteristics and seasonal shifts. Such phenotypic plasticity highlights the carp's capacity to adjust rapidly to contrasting ecological settings and to exploit local resources with notable efficiency.

Mean condition-factor (*K*) scores act as sensitive barometers of a fish's physiological state in relation to environmental quality and life-history demands. *C. gibelio* can survive in degraded waters yet markedly improves its condition under favourable circumstances. For that reason, systematic monitoring programmes should be implemented to track key biometric traits (especially length–weight relationships and condition factors) on a seasonal basis, thereby clarifying population-level responses to environmental change.

Future investigations should also focus on the mechanisms that underlie the species' growth plasticity and environmental adaptability. A deeper understanding of these processes will sharpen population-dynamics models and improve our capacity to gauge invasion risk, ultimately supporting more effective management of this invasive cyprinid in freshwater ecosystems.

CONFLICT OF INTEREST

No known or potential conflict of interest exist for any author.

REFERENCES

Ağdamar S and Gaygusuz Ö (2021). Condition, length-length and length-weight relationships for four introduced freshwater fish species from an island ecosystem (Gökçeada, Turkey). *Journal of Anatolian Environmental and Animal Sciences* 6(3): 403-408.

Anderson RO and Neumann RM (1996). Length, weight, and associated structural indices. In: Murphy BR, Willis DW (Eds.), *Fisheries Techniques* (2nd ed.), American Fisheries Society, Bethesda, pp. 447-482

Apaydın Yağcı M, Alp A, Yağcı A, Uysal R, Bilgin F, Cesur M, Yeğen V (2022). Length-weight relationships of ten fish species from Lake Eğirdir, Turkey. *Journal of Anatolian Environmental and Animal Sciences* 7(2): 105-109.

Bagenal TB and Tesch FW (1978). Age and growth. In: Bagenal TB (Ed.), *Methods for Assessment of Fish Production in Fresh Waters* (3rd ed.), Blackwell Scientific Publications, Oxford, pp. 101-136.

Baki B, Kaya Öztürk D, Uzun Gören G (2022). Determination of some biological characteristics of Prussian carp (*Carassius gibelio*): the example of Bafra Balik lakes (Türkiye). *International Journal of Fisheries and Aquatic Studies* 10(1): 64-71.

Balık İ, Özkök R, Çubuk H, Uysal R (2004). Investigation of some biological characteristics of the silver crucian carp, *Carassius gibelio* (Bloch, 1782) population in Lake Eğirdir. *Turkish Journal of Zoology* 28(1): 19-28.

Blackwell BG, Brown ML, Willis DW (2000). Relative weight (Wr) status and current use in fisheries assessment and management. *Reviews in Fisheries Science* 8(1): 1-44.

Bolger T and Connolly PL (1989). The selection of suitable indices for the measurement and analysis of fish condition. *Journal of Fish Biology* 34(2): 171-182.

Bostancı D, Polat N, Akyürek M (2007a). Some biological aspects of the crucian carp, *Carassius gibelio* Bloch, 1782 inhabiting in Eğirdir Lake. *International Journal of Natural and Engineering Sciences* 1(3): 55-58.

Bostancı D, Polat N, Kandemir Ş, Yılmaz S (2007b). Bafra Balık Gölü'nde yaşayan havuz balığı, *Carassius gibelio* (Bloch, 1782)'nun kondisyon faktörü ve boy-ağırlık ilişkisinin belirlenmesi. *SDÜ Fen Edebiyat Fakültesi Fen Dergisi (E-Dergi)* 2(2): 117-125.

Bulut S, Mert R, Algan B, Özbek M, Ünal B, Konuk M (2013). Several growth characteristics of an invasive cyprinid fish (*Carassius gibelio* Bloch, 1782). *Notulae Scientia Biologicae* 5(2): 133-138.

Çiçek E, Seçer B, Sungur S, Eagderi S, Bahçeci H (2022). Length-weight relationships and condition factors of eight exotic fish species from Türkiye. *Turkish Journal of Water Science & Management* 6(2): 260-274.

Copp GH, Bianco PG, Bogutskaya NG, Eros T, Falka I, Ferreira MT, et al. (2005). To be, or not to be, a non-native freshwater fish? *Journal of Applied Ichthyology* 21(4): 242-262.

Dereli H, Bayhan B, Ölçek ZS (2021). The life history of the non-native cyprinid fish *Carassius gibelio* (Bloch, 1782) from Demirköprü Reservoir in the Aegean Region in Turkey. *North-Western Journal of Zoology* 17(2): 187-195.

Emiroğlu Ö, Tarkan AS, Top N, Başkurt S, Sülün Ş (2012). Growth and life history traits of a highly exploited population of non-native gibel carp, *Carassius gibelio* from a large eutrophic lake (Lake Uluabat, NW Turkey): is reproduction the key factor for establishment success? *Turkish Journal of Fisheries and Aquatic Sciences* 12(4): 925-936.

Ergüden SA (2015). Age and growth properties of Prussian carp, *Carassius gibelio* (Bloch, 1782) living in the middle basin of Seyhan River in Adana, Turkey. *Pakistan Journal of Zoology* 47(5): 1365-1371.

Fazli H, Daryanabard GR, Janbaz A, Mirzaei R, Hosseinpour H, Vahedi N (2018). Some biological characteristics of *Carassius gibelio* (Bloch, 1782) in the Azad Dam Lake in Western Iran. *Iranian Journal of Ichthyology* 5(3): 243-249.

Froese R (2006). Cube law, condition factor and weight–length relationships: history, meta-analysis and recommendations. *Journal of Applied Ichthyology* 22(4): 241-253.

Gozlan RE, Britton JR, Cowx I, Copp GH (2010). Current knowledge on non-native freshwater fish introductions. *Journal of Fish Biology* 76(4): 751-786.

Hajiradkouchak E, Patimar R, Harsij M, Ghorbani R (2016). Study on growth properties of *Carassius gibelio* (Bloch, 1782) in Golestan and Voshmgir dam Lake of Golestan Province-Northern Iran Journal of Applied Ichthyological Research 9(4): 11-25.

İlhan A and Sarı HM (2015). Length-weight relationships of fish species in Marmara Lake, West Anatolia, Turkey. Croatian Journal of Fisheries 73(1): 30-32.

İlhan A, Sarı HM, Kurtul I (2020). Growth parameters of invasive gibel carp *Carassius gibelio* (Bloch, 1782) in Lake Marmara (Turkey). *Oceanological and Hydrobiological Studies* 49(4): 383-390.

İnnal D (2012). Age and growth properties of *Carassius gibelio* (Cyprinidae) living in Aksu River Estuary (Antalya-Turkey). *Review of Hydrobiology* 5(2): 97-109.

İnnal D, Çağlan DC, Özdemir F (2019). Fish species composition and length-weight relationships in Onaç Creek (Burdur-Turkey). Acta Biologica Turcica, 32(3): 135-142.

King M (2007). *Fisheries Biology, Assessment and Management* (2nd ed.). Blackwell Publishing, Oxford.

Kottelat M and Freyhof J (2007). *Handbook of European Freshwater Fishes*, Publications Kottelat, Cornol, Switzerland.

Le Cren (1951). The length-weight relationship and seasonal cycle in gonad weight and condition in the perch (*Perca fluviatilis*). *Journal of Animal Ecology* 20(2): 201-219.

Lizama M A P and Ambrósio A M (2002). Condition factor in nine species of fish of the Characidae family in the upper Paraná River floodplain, Brazil. *Brazilian Journal of Biology* 62(1): 113–124.

Reis İ, Cerim H, Ateş C (2019). Length-weight relationship of 13 fish species from the Lower Sakarya River, Turkey. *Aquatic Sciences and Engineering* 34(3): 86–89.

Ribeiro F, Elvira B, Collares-Pereira MJ, Moyle PB (2008). Life-history traits of non-native fishes in Iberian watersheds across several invasion stages: a first approach. *Biological Invasions* 10(1): 89–102.

Ricker W E (1975). Computation and interpretation of biological statistics of fish populations. Bulletin of the Fisheries Research Board of Canada, Bulletin 191.

Saç G and Okgerman H (2015). Growth and reproduction of a non-native fish species *Carassius gibelio* (Bloch, 1782) from Büyükçekmece Lake (Istanbul, Turkey). *IUFS Journal of Biology* 74(1): 1–12.

Sarı HM, Balık S, Ustaoğlu MR, İlhan A (2008). Population structure, growth and mortality of *Carassius gibelio* (Bloch, 1782) in Buldan Dam Lake. *Turkish Journal of Fisheries and Aquatic Sciences* 8(1): 25–29.

Stavrescu-Bedivan MM, Matei PB, Urdeş LD (2015). A Brief Survey of Length-Weight Relationship in Gibel Carp (*Carassius gibelio* Bloch, 1782) from Cişmigiu Lake. Scientific Papers. Series D. Animal Science 58: 391-394.

Sungur Birecikligil S, Çiçek E, Öztürk S, Seçer B, Celepoğlu Y (2016). Length-length, length-weight relationship and condition factor of fishes in Nevşehir Province, Kızılırmak River Basin (Turkey). Acta Biologica Turcica 29(3): 72-77.

Şimşek E and Kale S (2022). Length-weight relationship and condition factor of Prussian carp (*Carassius gibelio*, Bloch, 1782) from Asi River. *Journal of Agricultural Production* 3(2): 69–77.

Tarkan AS, Gaygusuz Ö, Acıpınar H, Gürsoy Ç, Özuluğ M (2006). Length-weight relationship of fishes from the Marmara region (NW-Turkey). *Journal of Applied Ichthyology* 22(4): 271–273.

Tarkan AS, Gaygusuz Ö, Acıpınar H, Gürsoy Gaygusuz Ç, Copp GH (2012). Circumstantial evidence of gibel carp (*Carassius gibelio*) as the most invasive fish in Turkish inland waters. *Journal of Applied Ichthyology* 28(4): 615–620.

Yalçın Özdilek Ş and Partal N (2022). Length-weight relationships and condition factors of three fish species in the Karamenderes Stream (Çanakkale, Türkiye). Turkish Journal of Bioscience and Collections 6(1): 21-25.

Yazıcı R and Saylar Ö (2022). Length-weight and length-length relationships and condition factor of an endemic fish species (Capoeta tinca (Heckel, 1843)) inhabiting Bayat Pond (Ankara, Türkiye). *Bilge International Journal of Science and Technology Research* 6(2): 132–137.

Yazıcıoğlu O, Yılmaz S, Yazıcı R, Polat N (2013). Ladik Gölü (Samsun, Türkiye)'nde Yaşayan Havuz Balığı, *Carassius gibelio* (Bloch, 1782)'nın Kondisyon Faktörü, Boy-Ağırlık ve Boy-Boy İlişkileri. Karadeniz Fen Bilimleri Dergisi 3(9): 72-80

Zar J H (1999). Biostatistical Analysis (4th ed.). Prentice Hall, Upper Saddle River.