LIMNOFISH-Journal of Limnology and Freshwater Fisheries Research 11(3): 129-137 (2025)

Journal of Limnology and Freshwater Fisheries Research

http://www.limnofish.org

# Some Biological Parameters and Otolith–Fish Size Relationships of the Endemic *Alburnoides kurui* Turan, Kaya, Bayçelebi, Bektaş & Ekmekçi, 2017 from the Tersakan Stream, Northern Anatolia

**Sefa BOZKURT[1], Savaş YILMAZ[1]***

[1] Department of Biology, Faculty of Sciences, Ondokuz Mayıs University, 55139, Samsun, Türkiye

**A B S T R A C T**

This study aims to examine the sex ratio, length and weight distribution, length–weight relationship, condition factor, and otolith morphometric relationships of the endemic freshwater fish *Alburnoides kurui* from the Tersakan Stream in Northern Anatolia. A total of 102 specimens were collected in November 2024 using electrofishing. The sample comprised 42 females, 46 males, and 14 individuals of undetermined sex, showing an approximately equal sex distribution. Total length ranged from 4.9 to 11.3 cm, and body weight from 0.92 to 15.62 g. Length–weight relationships were analyzed separately by sex, with allometric coefficients (*b*) ranging from 2.97 to 3.27; females exhibited positive allometric growth, whereas males showed isometric growth. Fulton's condition factor (*K*) and relative condition factor (*Kr*) varied by sex and size class, with females generally displaying higher and more variable *Kr* values. Strong relationships were observed between otolith measurements and fish length, with different otolith axes showing either isometric or allometric growth patterns, suggesting that different otolith axes are reliable predictors of fish size. This study represents the first comprehensive investigation of the biological traits and otolith morphometric relationships of *A. kurui*. Additionally, the observed maximum total length of 11.3 cm and weight of 15.62 g represent new maximum recorded values for the species.

**Keywords** *Alburnoides kurui*, endemic fish, length–weight relationship, condition factor, otolith morphometry

**A R T I C L E   I N F O**

**RESEARCH ARTICLE**

*Received* : 30.09.2025
*Revised* : 15.12.2025
*Accepted* : 25.11.2025
*Published* : 30.12.2025

DOI: 10.17216/LimnoFish.1793389

*** CORRESPONDING AUTHOR**

savas.yilmaz@omu.edu.tr
Phone : +90 362 312 1919/5437

**Kuzey Anadolu'daki Tersakan Çayı'ndan Endemik *Alburnoides kurui* Turan, Kaya, Bayçelebi, Bektaş & Ekmekçi, 2017'nin Bazı Biyolojik Parametreleri ve Otolit-Balık Boyutu İlişkileri**

**Öz:** Bu çalışma, Kuzey Anadolu'daki Tersakan Deresi'nden endemik tatlı su balığı *Alburnoides kurui*'nin eşey oranı, boy ve ağırlık dağılımı, boy–ağırlık ilişkisi, kondisyon faktörü ve otolit biyometrik ilişkilerini incelemeyi amaçlamıştır. Toplam 102 birey Kasım 2024 tarihinde elektroşokla elde edilmiştir. Örneklemede 42 dişi, 46 erkek ve 14 eşeyi belirlenemeyen birey bulunmuş ve yaklaşık eşit eşey dağılımı gözlemlenmiştir. Toplam boy 4,9–11,3 cm ve ağırlık 0,92–15,62 g aralığında değişmiştir. Boy–ağırlık ilişkileri eşeye göre ayrı analiz edilmiş ve allometrik katsayı (*b*) 2,97–3,27 aralığında bulunmuş; dişiler pozitif allometrik, erkekler izometrik büyüme göstermiştir. Fulton'un kondisyon faktörü (*K*) ve nispi kondisyon faktörü (*Kr*) değerleri eşey ve boy gruplarına göre değişiklik göstermiş, dişiler genellikle daha yüksek ve değişken *Kr* değerleri sergilemiştir. Otolit ölçümleri ile balık boyu arasında güçlü ilişkiler gözlenmiş olup farklı otolit eksenlerinin izometrik veya allometrik büyüme şablonu göstermesi, bu eksenlerin balık boyunun güvenilir göstergeleri olduğunu düşündürmektedir. Bu çalışma, *A. kurui*'nin biyolojik özellikleri ve otolit morfometrik ilişkileri üzerine yapılan ilk kapsamlı araştırmadır. Ayrıca, gözlemlenen 11,3 cm toplam boy ve 15,62 g ağırlık, tür için kaydedilmiş yeni maksimum değerleri temsil etmektedir.

**Anahtar kelimeler:** *Alburnoides kurui*, endemik balık, boy–ağırlık ilişkisi, kondisyon faktörü, otolit morfometrisi

**How to Cite**
Bozkurt S, Yılmaz S. 2025. Some Biological Parameters and Otolith–Fish Size Relationships of the Endemic *Alburnoides kurui* Turan, Kaya, Bayçelebi, Bektaş & Ekmekçi, 2017 from the Tersakan Stream, Northern Anatolia LimnoFish 11(3): 129-137. doi:10.17216/LimnoFish.1793389

## Introduction

Türkiye, with its complex geological structure, climatic diversity, and numerous isolated river basins, harbors remarkable biological richness, particularly in terms of endemic freshwater fishes (Çiçek et al. 2018; Giannetto and İnnal 2021). Among the most notable representatives of this diversity is the genus *Alburnoides* Jeitteles, 1861, belonging to the family Leuciscidae.

The genus *Alburnoides* is widely distributed across a broad area of the Palearctic region, ranging from Western Europe to Central Asia (Kottelat and Freyhof 2007). Globally, 34 valid species of this genus have been described, 22 of which are found in West Asia (Freyhof et al. 2025). In Türkiye, the genus occurs extensively in rivers and streams within the basins of the Marmara, Black, and Aegean seas, extending from the tributaries of the Büyük Menderes River in the west to the Euphrates and Tigris drainages in the east and southeast, as well as the Kura River drainage. However, the genus is naturally absent from the Mediterranean Sea basin (Geldiay and Balık 2007; Turan et al. 2013). Currently, 14 species of *Alburnoides* are recognized in Türkiye, seven of which are endemic (Freyhof et al. 2025).

*Alburnoides kurui* was first described by Turan et al. (2017) from the Tifi Stream in the Gökçebayır area of Ordu Province. The species is presently known only from the Yeşilırmak River Basin, where it inhabits clean, fast-flowing streams with gravel-substrate beds (Turan et al. 2017). The species is evaluated as category LC by the IUCN Red List (Freyhof et al. 2025). The restricted distributions of many endemic species described since 2000, combined with increasing anthropogenic pressures on freshwater habitats, underscore the urgent need for targeted conservation measures to secure their persistence (Kaya et al. 2025).

Previous studies on *A. kurui* have been predominantly taxonomic, whereas research on its biology and otolith morphometry has remained inadequate. For instance, Kurtul et al. (2024) analyzed 61 individuals from streams in the Yeşilırmak River Basin and reported the species' length–weight relationship and condition factor without considering sex differences. Similarly, Çetin and Yılmaz (2024) examined the morphology of lagenar and utricular otoliths from 17 specimens collected in the Tersakan Stream, using scanning electron microscopy. Therefore, this study aims to provide a more comprehensive analysis of the *A. kurui* population in the Tersakan Stream by investigating key biological traits, such as sex ratio, length and weight distribution, length–weight relationship, and condition factor, conducting these analyses separately for each sex to address prior limitations. Furthermore, the relationships between fish length and lagenar and utricular otolith measurements were explored.

## Materials and Methods

### Study Area and Sample Collection

The Tersakan Stream originates from Ladik Lake, located in the Ladik district of Samsun Province in the Central Black Sea region of Türkiye. The stream initially flows westward, subsequently turns southward and finally eastward before discharging into the Yeşilırmak River in the northern part of Amasya Province. The total length of this stream is approximately 100 km (Çetin and Yılmaz 2024). Specimens of *A. kurui* were collected on 1 November 2024 from a single station (40° 59′ 17.32″ N – 35° 45′ 29.51″ E) on the Tersakan Stream using an electrofishing device (SAMUS 725MP).

### Laboratory Processes

The collected fish specimens were transferred to the laboratory in a refrigerated storage container, rinsed with tap water, and gently dried with paper towels. Total length (*TL*, ±0.1 cm) and body weight (*W*, ±0.01 g) were recorded for each individual. Sex determination was conducted through macroscopic observation of the gonads, followed by microscopic examination at 10x magnification under a binocular microscope. However, the sex of 14 individuals could not be determined using these methods and was therefore coded as unknown. Subsequently, the lagenar (asteriscus) and utricular (lapillus) otoliths were extracted in pairs using forceps, rinsed with distilled water, air-dried at room temperature, and stored in plastic vials for further analyses. Otoliths could not be obtained from three specimens. High-resolution photographs of the proximal surfaces of the asterisci and the dorsal surfaces of the lapilli were taken with a Leica DF295 digital camera mounted on a Leica S8APO stereomicroscope with transmitted light illumination. All images were stored in JPEG format to ensure lossless quality. Morphometric parameters, including asteriscus length (*AL*, mm), asteriscus height (AH, mm), lapillus length (*LL*, mm), and lapillus width (*LW*, mm) (Figure 1), were subsequently measured using ImageJ software (version 1.53t).

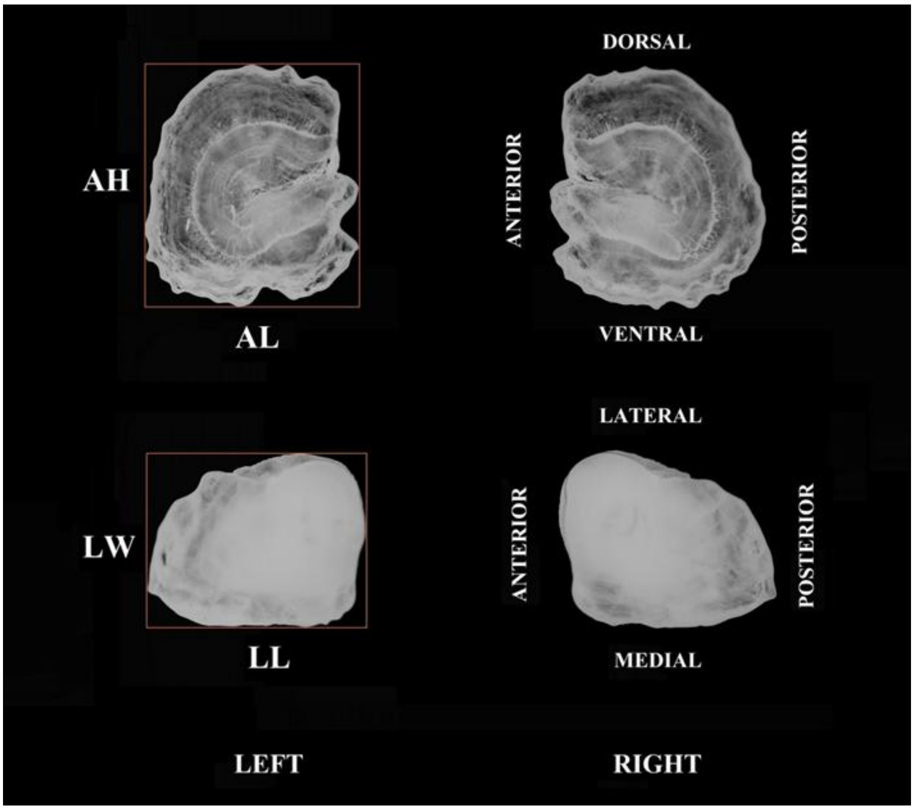


**Figure 1:** The proximal view of the asteriscus (top) and the dorsal view of the lapillus (bottom) from *Alburnoides kurui*, with the morphometric parameters (*AL*: asteriscus length, *AH*: asteriscus height, *LL*: lapillus length, *LW*: lapillus width) indicated.

**Data Processing and Formulae**

The relationship between total length and body weight was estimated according to Bagenal and Tesch (1978):

$W = aL^b$

Where *W* is fish weight (g), *L* is total length (cm), and *a* and *b* are the intercept and slope of the regression, respectively. The parameters of the length-weight relationship (*LWR*) were then calculated by linear regression using the logarithmically transformed values of this equation. *LWR*s were calculated separately for females, males, individuals of unknown sex, and the all specimens combined.

Fulton's condition factor (*K*) and relative condition factor (*Kr*) were used to evaluate fish condition. Fulton's condition factor (Ricker 1975) assumes that both weight and length increase isometrically and is calculated with the following equation:

$K = W/L^3 \times 100$

Where *W* is body weight (g) and *L* is fish length (cm). The relative condition factor, proposed by Le Cren (1951), assumes that fish growth is standard and not necessarily isometric and is calculated with the following equation:

$Kr = W/aL^b$

Where *a* and *b* are parameters of the length-weight relationship. Condition factor values were calculated for each individual and analyzed separately by sex and by 1-cm length group.

Due to the significant difference in fish size between sexes (Mann–Whitney U test, $P = 0.014$), all otolith measurements were adjusted according to the formula below (Lleonart et al. 2000):

$M_{adj} = M \times (L_O/L)^b$

Where $M_{adj}$ is the adjusted measurement, *M* is the original measurement, *L* is the fish length, $L_O$ is the overall mean length of the sample, and *b* is the allometric coefficient obtained from the log–log regression of the measurement on fish length.

The relationships between otolith measurements and fish size were analyzed using a power function:

$Y = aX^b$

Where *Y* represents the otolith dimension, *X* is the fish length, *a* is the intercept, and *b* the slope. The parameters *a* and *b* were estimated via linear regression on logarithmically transformed data:

$Log\ Y = Log\ a + b\ Log\ L.$

**Statistical Analysis**

Prior to the analyses, the assumption of normality was evaluated using the Shapiro–Wilk test, while the homogeneity of variances was assessed with Levene's test. The sex ratio of *A. kurui* specimens was evaluated for deviations from the expected 1:1 ratio using the Chi-square ($\chi^2$) test. The difference in mean total length between females and males was analyzed with a *t*-test, while the difference in body weight was assessed using the Mann-Whitney U test. The *b* coefficient of the *LWR* was compared between females and males using analysis of covariance (ANCOVA), with sex as the main factor and *TL* as a covariate. Growth type was determined from *b* values using a *t*-test, with $b = 3$ indicates isometric growth, $b < 3$ indicates negative allometric growth, and $b > 3$ indicates positive allometric growth. Differences in mean *K* and *Kr* values between females and males were assessed using a *t*-test when the data met parametric assumptions; otherwise, the Mann-Whitney U test was applied. The Wilcoxon test was applied to evaluate the differences between left and right otolith measurements. Standardized otolith measurements were compared between male and female individuals using the *t*-test. The effect of sex on the *b* coefficient in otolith–somatic growth relationships was evaluated using ANCOVA. The slope of each regression was compared against the isometric value ($b = 1$) using a *t*-test (Zar 1999).

## Results

### Sex Composition

A total of 102 specimens of *A. kurui* were collected, comprising 42 females, 46 males, and 14 individuals of unknown sex. The female-to-male ratio was calculated as 1:1.095. Chi-square analysis indicated that this ratio did not differ significantly from the expected 1:1 ratio ($\chi^2 = 0.182$, $P = 0.670$), suggesting an approximately equal sex distribution within the sampled population.

### Length and Weight Distributions

The total length of *A. kurui* specimens ranged from 4.9 to 11.3 cm (mean ± *SD* 8.19 ± 1.51 cm), while body weight varied between 0.92 and 15.62 g (mean ± *SD* 5.88 ± 3.44 g). The mean total length differed significantly between females and males (*t*-test, $P = 0.025$), and the mean body weight also showed a significant difference between sexes (Mann–Whitney test, $P = 0.015$). Detailed descriptive statistics by sex are presented in Table 1.

**Table 1.** Descriptive statistics of total length and body weight of *Alburnoides kurui* from the Tersakan Stream

| Sex | *N* | Total length (cm) | | Weight (g) | |
|---|---|---|---|---|---|
| | | Mean±*SD* | Min–Max | Mean±*SD* | Min–Max |
| Female | 42 | 8.11±1.71 | 4.9–11.3 | 5.93±4.16 | 0.92–15.62 |
| Male | 46 | 8.80±1.00 | 6.8–11.1 | 6.87±2.46 | 3.08–13.57 |
| Unknown | 14 | 6.45±0.68 | 5.1–7.4 | 2.49±0.76 | 1.14–3.82 |
| Total | 102 | 8.19±1.51 | 4.9–11.3 | 5.88±3.44 | 0.92–15.62 |

*N: sample size, SD: standard deviation, Min: minimum, Max: maximum*

The length-frequency distributions indicated that males were primarily concentrated in the 8–9 cm size classes, while females were more evenly distributed across 6–9 cm (Figure 2a). In contrast, individuals of unknown sex were restricted to the smaller size classes (5–7 cm). Similarly, weight-frequency distributions revealed that males predominated in the higher weight classes (6–8 g), whereas females exhibited a wider distribution extending up to 16 g (Figure 2b).

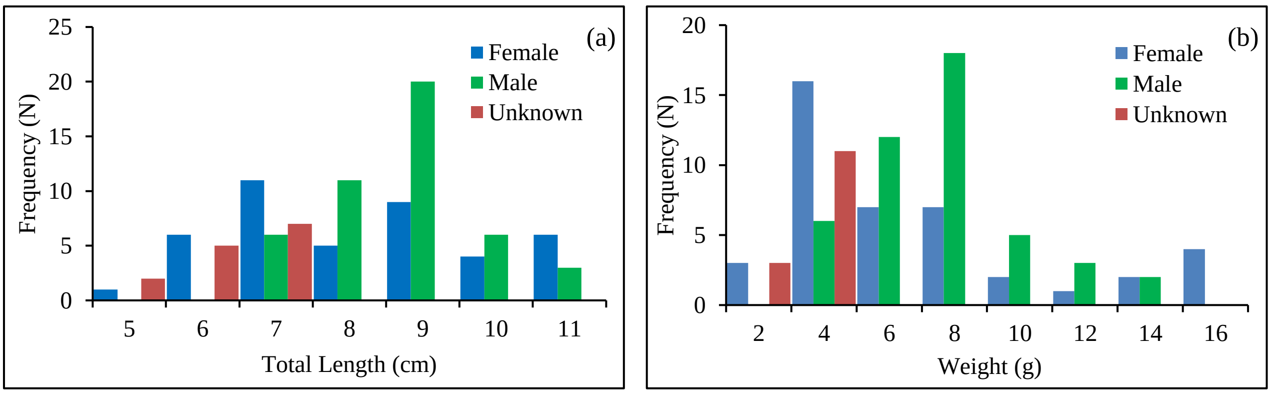


**Figure 2:** Length- (a) and weight-frequency (b) distributions of *Alburnoides kurui* from the Tersakan Stream

### Length-Weight Relationship

The length–weight relationships of *A. kurui* are presented in Table 2. The estimated *b* values varied slightly between sexes, ranging from 3.092 in males to 3.265 in females. Females exhibited positive allometric growth ($b > 3$, $P < 0.05$), whereas males showed isometric growth ($b = 3$, $P > 0.05$). The coefficients of determination ($R^2$) were high (0.985–0.993), indicating strong length–weight relationships across all groups. ANCOVA revealed a significant difference in the *LWR* slope (*b* value) between females and males ($F = 5.009$, $P = 0.028$).

**Table 2.** Estimated parameters of the length–weight relationship (*LWR*) of *Alburnoides kurui* from the Tersakan Stream

| | | Parameters of the LWR | | | | |
|---|---|---|---|---|---|---|
| Sex | *N* | *a* | *b*±*SE* | 95% *CI* of *b* | $R^2$ | Growth type |
| Female | 42 | 0.005 | 3.265±0.043 | 3.178–3.351 | 0.993 | (+) Allometry |
| Male | 46 | 0.008 | 3,092±0.058 | 2.975–3.208 | 0.985 | Isometry |
| Unknown | 14 | 0.006 | 3.204±0.094 | 3.001–3.407 | 0.990 | (+) Allometry |
| Total | 102 | 0.006 | 3.229±0.027 | 3.175–3.282 | 0.993 | (+) Allometry |

*N: sample size, SE: standard error, CI: confidence interval, $R^2$: coefficient of determination*

### Condition Factor

The mean *K* value for all individuals was 0.95; sex-specific means were 0.95 for females and 0.97 for males. The mean *Kr* averaged 0.98 overall, with females exhibiting higher values (1.09) than males (0.99). Individuals of unknownsex showed intermediate *K* (0.89) and *Kr* (1.02) values (Table 3). Statistical analysis revealed that Fulton's condition factor did not differ significantly between sexes (*t*-test, $P = 0.179$), whereas relative condition factor differed significantly (*t*-test, $P < 0.001$).

**Table 3.** Descriptive statistics of Fulton's condition factor (*K*) and relative condition factor (*Kr*) of *Alburnoides kurui* specimens from the Tersakan Stream

| Variable | Sex | *N* | Mean±*SD* | Min–Max |
|---|---|---|---|---|
| *K* | Female | 42 | 0.95±0.07 | 0.78–1.11 |
| | Male | 46 | 0.97±0.05 | 0.87–1.08 |
| | Unknown | 14 | 0.89±0.03 | 0.81–0.94 |
| | Total | 102 | 0.95±0.06 | 0.78–1.11 |
| *Kr* | Female | 42 | 1.09±0.06 | 0.98–1.23 |
| | Male | 46 | 0.99±0.05 | 0.90–1.12 |
| | Unknown | 14 | 1.02±0.03 | 0.96–1.06 |
| | Total | 102 | 0.98±0.05 | 0.88–1.12 |

*N: sample size, SD: standard deviation, Min: minimum, Max: maximum.*

Mean *K* in females ranged from 0.78 in the 5 cm size group to 1.05 in the 11 cm group, while in males it ranged from 0.94 (7 cm) to 1.01 (11 cm). Females exhibited a gradual increase in *K* with body size, whereas males maintained relatively stable values across size groups (Figure 3a). No significant differences in mean *K* were detected between sexes within the same size classes ($P > 0.05$). Mean *Kr* in females varied between 1.07 (8 cm) and 1.14 (6 cm), while male *Kr* values ranged from 0.98 (7–10 cm) to 1.02 (11 cm). Overall, females displayed higher and more variable *Kr* values compared to males, which were lower and more consistent (Figure 3b). Significant differences in mean *Kr* between sexes were observed in the 7, 9, and 11 cm size groups ($P < 0.05$).

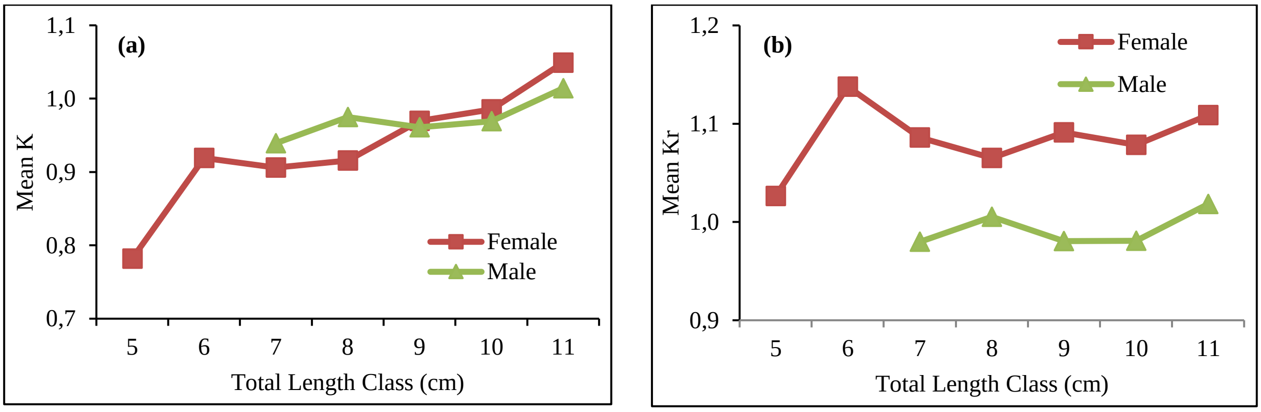


**Figure 3.** Mean condition factor values by total length class in female and male *Alburnoides kurui* from the Tersakan Stream. (a): Fulton's condition factor (*K*), (b): relative condition factor (*Kr*)

**Otolith–Fish Size Relationships**

The Wilcoxon test indicated no significant differences between left and right otolith measurements for both asteriscus and lapillus (Table 4). Therefore, only data from the right otoliths were used in subsequent analyses.

Descriptive statistics of otolith variables are presented in Table 5. A significant difference between sexes was detected in *AL* (*P = 0.024*), whereas no variation between females and males was observed in *AH* (P = 0.893), *LL* (*P = 0.616*), and *LW* (*P = 0.439*). The ANCOVA test revealed no significant differences in the slopes of the regressions between females and males for the relationships of *TL-AL* (*F = 0.622*, *P = 0.433*), *TL-AH* (*F = 0.928*, *P = 0.338*), *TL-LL* (*F = 0.282*, *P = 0.597*), and *TL-LW* (F = 0.301, *P = 0.585*). Consequently, data from both sexes were pooled to establish a general relationship for each variable.

The relationships between total fish length (*TL*) and all four otolith dimensions were highly significant (*P* < 0.001 for all) and the regression models showed strong coefficients of determination ($R^2$ > 0.89) (Table 6). The relationship between *TL* and lapillus length (*LL*) was isometric (*t* = 0.48, *P* = 0.634), indicating proportional growth. In contrast, lapillus width (*LW*) showed positive allometric growth (*t* = 2.36, *P* = 0.020), meaning it increased at a faster rate than body length. Conversely, both asteriscus length (*AL*) and height (*AH*) displayed negative allometric growth (*t* = -4.18, *P* = 0.000 for *TL–AL* and *t* = -3.31, *P* = 0.001 for *TL–AH*), indicating that these dimensions increased at a slower rate compared to the overall growth of the body.

**Table 4.** Descriptive statistics and Wilcoxon test results for left and right otolith measurements of *Alburnoides kurui* from the Tersakan Stream

| Measure | *N* | Side | Mean±*SD* | Min–Max | *P* |
|---|---|---|---|---|---|
| *AL* | 198 | Left | 1.160±0.217 | 0.809–1.754 | 0.149 |
| | | Right | 1.154±0.221 | 0.729–1.741 | |
| *AH* | 198 | Left | 1.340±0.240 | 0.823–1.983 | 0.428 |
| | | Right | 1.342±0.242 | 0.836–1.963 | |
| *LL* | 198 | Left | 1.191±0.212 | 0.729–1.807 | 0.840 |
| | | Right | 1.194±0.236 | 0.705–1.830 | |
| *LW* | 198 | Left | 0.845±0.179 | 0.521–1.365 | 0.917 |
| | | Right | 0.845±0.179 | 0.509–1.314 | |

*N: sample size, SD: standard deviation, Min: minimum, Max: maximum, P: probability*

**Table 5.** Sex-specific descriptive statistics of right otolith measurements in *Alburnoides kurui* collected from the Tersakan Stream

| Sex | *N* | Asteriscus length Mean±*SD* (Min–Max) | Asteriscus height Mean±*SD* (Min–Max) | Lapillus length Mean±*SD* (Min–Max) | Lapillus width Mean±*SD* (Min–Max) |
|---|---|---|---|---|---|
| Female | 42 | 1.157±0.261 (0.729–1.741) | 1.329±0.275 (0.836–1.963) | 1.184±0.271 (0.705–1.830) | 0.840±0.206 (0.509–1.314) |
| Male | 44 | 1.217±0.158 (0.896–1.488) | 1.436±0.165 (1.132–1.809) | 1.282±0.164 (0.998–1.679) | 0.908±0.126 (0.701–1.237) |
| Total | 99 | 1.154±0.221 (0.729–1.741) | 1.342±0.242 (0.836–1.963) | 1.195±0.236 (0.705–1.830) | 0.845±0.179 (0.509–1.314) |

*N: sample size, SD: standard deviation, Min: minimum, Max: maximum*

**Table 6.** Regression parameters of the allometric relationships between otolith dimensions and fish body size in *Alburnoides kurui* from the Tersakan Stream

| Relationship | *N* | Regression parameters | | | Growth type |
|---|---|---|---|---|---|
| | | *a*±*SE* | *b*±*SE* | $R^2$ | |
| *TL* vs. *AL* | 99 | 0.155±0.011 | 0.954±0.033 | 0.898 | (–) Allometry |
| *TL* vs. *AH* | 99 | 0.188±0.008 | 0.934±0.020 | 0.958 | (–) Allometry |
| *TL* vs. *LL* | 99 | 0.142±0.007 | 1.011±0.023 | 0.950 | Isometry |
| *TL* vs. *LW* | 99 | 0.090±0.005 | 1.066±0.028 | 0.937 | (+) Allometry |

*N: sample size, SE: standard error, a: intercept, b: slope, $R^2$: coefficient of determination*

## Discussion

This study provides the first comprehensive investigation of the biological characteristics and otolith morphometry of *A. kurui* from the Tersakan Stream and contributes significant new data to FishBase, including new maximum records for total length (11.3 cm) and body weight (15.62 g) for the species. The sex ratio of the sampled population was found to be nearly 1:1, indicating no pronounced imbalance between sexes. This balanced sex ratio could result from similar survival rates or comparable longevity between the sexes (Patimar et al. 2012). Nikolsky (1963) highlighted that the sex ratio in many fish species tends to approach 1:1, but also noted that it may vary among species, among populations of the same species, and even from year to year within a single population. The length (4.9–11.3 cm) and weight (0.92–15.62 g) ranges identified in the present study were broader than those reported by Kurtul et al. (2024) for specimens collected from different streams in the Yeşilırmak Basin (length: 5.2–10.4 cm; weight: 1.20–11.02 g). Such differences are likely attributable to variation in sampling time, methods, and sample size.

Strong relationships were observed between total length and body weight ($R^2 > 0.98$). The estimated *b* values were within the expected range of 2.5–3.5 (Froese 2006). Positive allometric growth was observed in females and the pooled sample, indicating that they gain body mass disproportionately to their length as they grow, whereas males exhibited isometric growth, where increases in length and weight are proportional (Wootton 1990). Similarly, Kurtul et al. (2024) reported a *b* value of 3.1214 for *A. kurui*, which also indicated positive allometric growth. Length–weight relationships in fishes are known to be influenced by a variety of factors, including habitat, locality, season, stomach fullness, gonadal maturity, sex, health, preservation techniques, and the observed size ranges of the sampled individuals (Bagenal and Tesch 1978; Wootton 1990).

The condition factor is a key biometric index reflecting the health status and nutritional adequacy of fish (Wootton 1990). In this study, two indicators were used to evaluate the condition of *A. kurui*. Fulton's condition factor (*K*) enables comparisons among different populations of the same species, whereas the relative condition factor (*Kr*) reflects variation among individuals within a single population (Wootton 1990). In the Tersakan population, no sexual dimorphism was detected in mean *K* values, with an overall mean of 0.95 (range 0.78–1.11). By contrast, Kurtul et al. (2024) reported a mean *K* of 1.006 (range 0.837–1.266). The discrepancies between studies could be due to the pooling of fish collected from different streams within the Yeşilırmak Basin and their preservation in formalin in the previous study. In the present study, mean *K* gradually increased with size in females, while remaining relatively stable in males. Mean *Kr* values also differed between sexes, with females showing higher values than males, suggesting better overall condition in females. This pattern likely reflects the higher energetic reserves required for vitellogenesis and other reproductive processes in females during the pre-spawning period. When analyzed by length groups, females exhibited higher and more variable *Kr* values, whereas males showed lower and more stable values. According to Le Cren (1951), $Kr \geq 1$ indicates that fish are good condition, while $Kr < 1$ indicates poor condition. Fluctuations in condition factor mainly reflect feeding intensity and gonadal development (Wootton 1990). Nonetheless, several environmental and biological factors—such as habitat, season, age, and reproductive period—may also influence the condition factor (Williams 2000). These variables, however, were not considered in the present study. It should also be noted that the present study was based on samples collected only in November. Therefore, the results and interpretations reflect the biological status of the population during this specific period and may not represent potential seasonal variations in growth or condition. For this reason, it is recommended that future studies include seasonal sampling to better evaluate temporal variability in these parameters.

The lagenar and utricular otoliths of *A. kurui* were previously morphologically characterized by Çetin and Yılmaz (2024). In contrast, the present study provides the first data on the relationships between otolith measurements and fish size for this species. No significant differences was observed between the left and right asteriscus and lapillus morphometrics, indicating that otolith–fish size relationships can be reliably obtained using either the left or right otolith. This finding is consistent with previous studies (Yılmaz et al. 2014; Yazıcı et al. 2020; Saygın et al. 2024; Özpiçak et al. 2024).

The analysis of otolith–fish size relationships revealed distinct growth patterns for different otolith dimensions. The isometric growth observed between total length and lapillus length (*LL*) suggests that *LL* increases in direct proportion to fish growth, making it a reliable proxy for estimating body size of *A. kurui*. This finding is consistent with studies on other fish species where lapillus length has shown a strong and proportional relationship with somatic growth (Yılmaz et al. 2019; İmamoğlu et al. 2024). In contrast, the positive allometric growth of lapillus width (*LW*) indicates that the lapillus becomes relatively wider as the fish grows larger, potentially leading to shape changes (e.g., a more oval or rounded form). Conversely, both asteriscus length (*AL*) and height (*AH*) exhibited negative allometric growth, meaning their dimensions increased at a slower rate compared to the overall body growth. This differential growth likely reflects the distinct functional roles of the lapillus (balance) and asteriscus (hearing) (Schulz-Mirbach et al. 2019), and may represent a species-specific strategy for allocating resources to sensory structures. These morphometric relationships provide a fundamental tool for future ecological studies, such as back-calculating fish size from otoliths found in predator diets or fossil records.

In conclusion, this study provides the first comprehensive baseline data on the biological traits and otolith-fish size relationships of the endemic *A. kurui*. The findings on length-weight relationships, condition factors, and particularly the distinct allometric patterns of different otolith dimensions, not only enhance our understanding of the life history of this species but also establish a crucial foundation for its future monitoring, conservation, and for applications in fields such as trophic ecology and paleoichthyology

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