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# A study on some biological parameters of the population of *Chondrostoma angorense* Elvira, 1987 (Actinopterygii: Cypriniformes: Leuciscidae) in the Devrez River, Türkiye

by

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## Abstract

Understanding the biological characteristics of fishes is essential for conserving native, particularly endemic species and providing accurate recommendations for fisheries management. In Türkiye, studies on the endemic Ankara nase, *Chondrostoma angorense*, are rare, and no data are available on its reproductive biology. This study provides some biological parameters of *C. angorense*, including population age structure, growth, and reproductive characteristics, from the Devrez River. Fish specimens were sampled monthly from April 2020 to March 2021 using a cast net. The overall ratio of males to females was 0.98:1, with an age distribution of I–V age groups. The length–weight relationship and von Bertalanffy growth function were estimated as $\log W = -1.9586 + 3.0039 \log (L)$ and $L_t = 32.64\ (1 - e^{-0.109\ (t + 1.870)})$, respectively. The maturity ogives indicated that 50% of males and females reached sexual maturity at total lengths (TLs) of 14 cm and 16 cm and weights of 25 g and 34 g, respectively. *C. angorense* had a protracted spawning season lasting from March to June. The absolute fecundity ranged from 1015 to 10 664 oocytes, with an average of 5130. Fecundity was positively correlated with fork length, total weight, gonad weight, and age.

**Key words:** Anatolia, endemism, fecundity, GSI, length–weight relationship, spawning

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# 1. Introduction

The genus *Chondrostoma* Agassiz, 1832, is found in most rivers and streams in Türkiye, and 14 species have been identified in Turkish waters (Çiftçi et al., 2020; Güçlü et al., 2018; Küçük et al., 2023). Ankara nase (*Chondrostoma angorense* Elvira, 1987) is an endemic cyprinid fish with a natural distribution in the Sakarya and Kızılırmak River basins of northwestern Anatolia (Elvira, 1997). Having a fusiform shape, this rheophilic fish inhabits fast-flowing waters, is frequently found near or on the stone bottom, and employs the horny edges of its lower jaw to adeptly scrape algae from rocky surfaces. Locally, this species has some commercial value for recreational fisheries, along with *Squalius* sp., *Capoeta tinca*, and *Barbus anatolicus* (Gürbüz, 2023). Although *C. angorense* is listed as Least Concern according to the IUCN Red List of Threatened Species (Freyhof, 2014), its current population trends are decreasing in the face of increasing threats (Emiroğlu et al., 2020), especially anthropogenic activities (Gürbüz, 2023).

There is hardly any study on the life history of *C. angorense*. Considering previous studies, the length–weight relationships of *C. angorense* were identified from Seydisuyu, a tributary of the Sakarya River, Türkiye (Emiroğlu et al., 2020). Other studies reported the habitats where *C. angorense* was found (Tarkan et al., 2007; Yoğurtçuoğlu et al., 2020) or investigated the molecular phylogeny (Çiftçi et al., 2020) and taxonomy of the *Chondrostoma* genus (Küçük et al., 2023).

Effective conservation efforts require a thorough examination of the species' biology to inform strategic planning. The assessment of growth dynamics, fecundity, and sexual maturity attainment are crucial elements in both fish biology and fisheries research. In this regard, the purpose of this study was to document data on life history attributes and population age structure of endemic *C. angorense* to provide a basis for conservation measures. The main objectives of this study were to identify gradients in growth, the length–weight relationship, the number of age groups present, and reproductive performance, such as sex ratio, gonadal maturation, spawning season, fecundity, and oocyte size, of the *C. angorense* population in the Devrez River.

# 2. Materials and methods

## 2.1. Study area

The study was conducted in the Devrez River, situated in the northern part of Anatolia, Türkiye (Fig. 1). Fish samples were collected from five different sampling sites with the following coordinates—Sampling site 1: 40°58′34″N, 34°04′40″E; Sampling site 2: 40°53′58″N, 33°39′30″E; Sampling site 3: 40°50′16″N, 33°23′46″E; Sampling site 4: 40°46′37″N, 33°17′05″E; Sampling site 5: 40°37′02″N, 33°02′08″E. The Devrez River is a large tributary of the Kızılırmak River basin, spanning 186 km in length, with a basin area of 336 400 ha and a flow rate of 4.081 $m^3 \cdot s^{-1}$. The region's climate is influenced by both the oceanic climate of the Black Sea region and the terrestrial climate of Central Anatolia. Precipitation fluctuates annually within the basin, ranging from 348 mm to 545 mm. The basin experiences lower precipitation levels, below Türkiye's average (573.4 mm), mostly concentrated in winter and spring, contributing to irregular flow patterns. The ground of the Devrez River is stony and sandy, forming deep ponds in some places (DSI, 2014). The fish species in the Devrez River include *C. angorense, C. tinca, B. anatolicus*, *Alburnoides freyhofi*, *Alburnus escherichii*, *Alburnus goekhani*, *Oxynoemacheilus angorae*, *Oxynoemacheilus samanticus*, *Oxynoemacheilus seyhanensis, Rhodeus amarus, Neogobius fluviatilis, Pseudorasbora parva, Squalius* sp., *Alburnus derjugini*, and *A. escherichii* (Gürbüz, 2023; Yoğurtçuoğlu et al., 2020).

## 2.2. Sampling method and determination of sex

In total, 103 fish samples were collected monthly from April 2020 to March 2021 using cast nets with mesh sizes ranging from 12 mm to 25 mm, with assistance from local fishermen. The captured samples were stored in ice and transported to the Hydrobiology Laboratory, Ankara Haci Bayram Veli University. The fork length (FL) and total length (TL) were measured to the nearest 1 mm using an L-shaped board, and an electronic balance (ISOLAB I.602.31.006; Eschau, Germany) was used to record body weight (W) to the nearest 0.1 g immediately. Age was determined from scales, which were taken above the lateral line, below the anterior part of the dorsal fin (Lagler, 1956). All fish specimens were dissected. Gonads were removed, weighed to the nearest 0.01 g using an electronic balance, and preserved in 4% formaldehyde. Sex was assessed by visually inspecting gonad tissue in larger fish and using a stereo microscope (ISOLAB LM18133M010) for smaller ones.

## 2.3. Length–weight relationships and condition factor (CF)

The length–weight relationship was determined using the equation:

$$W = aL^b \quad (1)$$

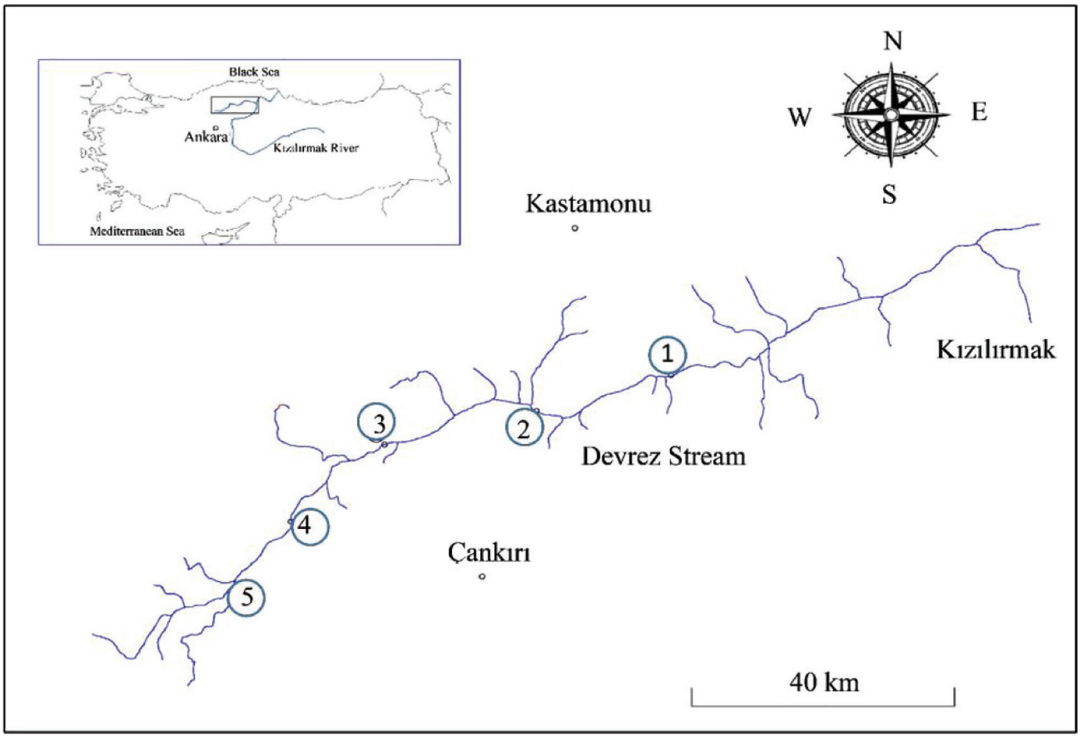


**Figure 1**

Map of the Devrez River and sampling sites.

which can be transformed into its logarithmic form:

$$\log W = \log (a) + b \times \log (L) \quad (2)$$

where $W$ is the total weight (g), $L$ is the FL (cm), $b$ is the growth exponent, and $a$ is a constant. The growth exponent $b$ generally lies between 2.5 and 3.5, but the relationship is reported to be isometric when $b = 3$ and allometric when $b$ is a value other than 3 (Ricker, 1975).

Growth in terms of length was estimated using the von Bertalanffy growth function (VBGF):

$$L_t = L_\infty (1\text{-}e^{-K(t-t0)}) \quad (3)$$

where $Lt$ is the length at age $t$, $L_\infty$ is the theoretical maximum (or asymptotic) length that the species would reach if it lived indefinitely, $K$ is a growth coefficient that is a measure of the rate at which maximum size is reached, and $t_0$ is the hypothetical age at length zero. Fulton's CF was calculated using the formula:

$$CF = (W/L^3) \times 100 \quad (4)$$

where $W$ is the total weight (g) and $L$ is the FL (cm) (Ricker, 1975).

### 2.4. Identification of maturity stages and gonadosomatic index (GSI)

The stage of gonadal development was identified for each female individual. Gonadal maturity was assessed using a six-stage scale (Nikolsky, 1963). The stages are as follows:

- Stage I: Immature individuals that have not yet spawned.
- Stage II: Due to the small size of the gonads, oocytes are not visible to the naked eye.
- Stage III: The ripening stage occurs when oocytes start to become visible.
- Stage IV: The ripe stage indicates that gonads have reached their maximum weight.
- Stage V: The reproduction stage, characterized by gametes being expelled with the slightest pressure applied to the thorax. The weight of the gonads decreases rapidly from the beginning to the end of the spawning process.
- Stage VI: The spent stage is characterized by gonads that resemble empty sacs, usually with a few oocytes still present in females.

Sexual maturity and spawning periods were determined based on monthly variations in the GSI and the diameters of oocytes in the samples (Nikolsky, 1963). The GSI was calculated monthly for each fish using the equation:

$$GSI\% = (Wg/Wt) \times 100 \quad (5)$$

where *Wg* and *Wt* are the gonad weight (GW) and total body weight of fish (g), respectively. The monthly mean GSI was depicted on a line graph, where the increasing peak denotes the spawning season for the species.

### 2.5. Size at first sexual maturity

The size at first sexual maturity is defined as the length at which 50% of the captured individuals reach maturity ($L_{50}$) during the breeding season. This was calculated based on the percentage of mature individuals reaching stage III and above within each size class, and a logistic function was fitted to the proportion of mature individuals by size class using non-linear regression. The function used was:

$$P_r = 1/[1 + \exp(-r (L–L_m))] \quad (6)$$

where $P_r$ is the proportion mature in each size class, *r* (-*b* slope) is a parameter controlling the shape of the curve, and $L_m$ is the size at 50% maturity ($L_m = a/r$), where *a* is the *x*-axis intercept (Saila et al., 1988).

### 2.6. Fecundity

Fecundity (*F*) was calculated using the gravimetric method described by Bagenal and Braum (1978), involving a 2-hr rinsing of the ovaries with water, followed by the extraction of three 1 g subsamples from the front, middle, and rear portions of each mature ovary. The oocytes in the subsamples were counted. The total number of oocytes in each ovary was proportional to total ovary weight. Relative fecundity ($F_r$) was calculated as:

$$F_r = F/W \text{ (g)} \quad (7)$$

where *W* is the body weight of fish (g), and

$$F_r = F/FL \text{ (cm)} \quad (8)$$

Relationships between *F* and FL; *F* and *W*, *F*, and GW; and *F* and age (*t*) were determined using the equation:

$$F = axb \quad (9)$$

where *F* is fecundity; *x* is FL, *W*, GW, or *t*; *a* is a constant; and *b* is an exponent (Bagenal & Braum, 1978). The diameters of 30 oocytes sampled from the front, middle, and rear sections of mature ovaries were measured using a micrometer.

### 2.7. Statistical analysis

Chi-square ($\chi^2$) analysis was used to compare the sex ratio of males to females with the theoretical sex ratio of 1:1. The significance of differences in growth, mean CF values, and mean TL-at-age between males and females was determined using Student's *t*-test, with differences considered significant at the a $\alpha < 0.05$ level. The data were analyzed using Microsoft Excel and Grapher 3. The results were expressed as mean ± standard deviation (SD). The coefficient of determination ($r^2$) was employed to quantify the strength of the linear relationship. The sizes and numbers of oocytes from three different parts of the ovary were statistically compared using a single-factor analysis of variance (ANOVA).

## 3. Results

### 3.1. Sex ratio, age distribution, and length frequency

Overall, 103 *C. angorense* were aged, with the age-3 group being dominant (45.6%) in the population (Table 1). Males were dominant in the younger age groups, and there were only two female fish greater than 4 years of age. The sex ratio of males ($n = 51$) to females ($n = 52$) was 0.98:1.00, which did not differ significantly from a ratio of 1.00: 1.00 (($\chi^2 = 0.02 <$ ($\chi^2_{1,0.05} = 3.84$). The mean TL ranged from 13.2 cm for 1-year-old fish to 23.7 cm for 5-year-old fish (Table 1). Males in the 2- and 3-year age groups were longer than females in the population. The differences between the mean TL of males and females were not statistically significant (Student's *t*-test, $t = 0.27$; d.f. = 101; $p > 0.05$).

### 3.2. Length–weight relationships and CF

The estimated relationship between length and weight was log $W = –1.8386 + 2.8998$ log (*L*) for males ($n = 51$; $r^2 = 0.965$), log $W = –2.0315 + 3.0688$ log (*L*) for females ($n = 52$; $r^2 = 0.947$), and log $W = –1.9586 + 3.0039$ log (*L*) for the sexes combined ($n = 103$; $r^2 = 0.944$). The growth of *C. angorense* population in the Devrez River was found to be isometric (Fig. 2), but males showed negative allometric growth ($b = 2.8998$). The slope values

**Table 1**

Mean length and CF-at-age of *Chondrostoma angorense* in the Devrez River.

| Age (years) | TL (cm) | | | | | | | CF | |
|---|---|---|---|---|---|---|---|---|---|
| | Female | | Male | | Female and Male | | | Female and Male | |
| | n | Mean ± SD | n | Mean ± SD | n | Mean ± SD | Range | Mean ± SD | Range |
| I | - | - | 5 | 13.2 ± 0.91 | 5 | 13.2 ± 0.91 | 11.8–14.0 | 1.12 ± 0.05 | 1.06–1.17 |
| II | 5 | 14.9 ± 2.51 | 11 | 16.8 ± 0.90 | 16 | 16.0 ± 1.74 | 11.4–17.8 | 1.10 ± 0.06 | 0.96–1.23 |
| III | 26 | 18.3 ± 1.72 | 21 | 19.2 ± 1.00 | 47 | 18.6 ± 1.44 | 16.0–22.2 | 1.11 ± 0.09 | 0.80–1.33 |
| IV | 19 | 21.7 ± 1.50 | 14 | 21.1 ± 1.10 | 33 | 21.4 ± 1.32 | 19.6–24.1 | 1.12 ± 0.11 | 0.83–1.47 |
| V | 2 | 23.6 ± 0.21 | - | - | 2 | 23.7 ± 0.21 | 23.5–23.8 | 1.22 ± 0.03 | 1.20–1.24 |

CF, condition factor; *n*, number of fish; SD, standard deviation; TL, total length.

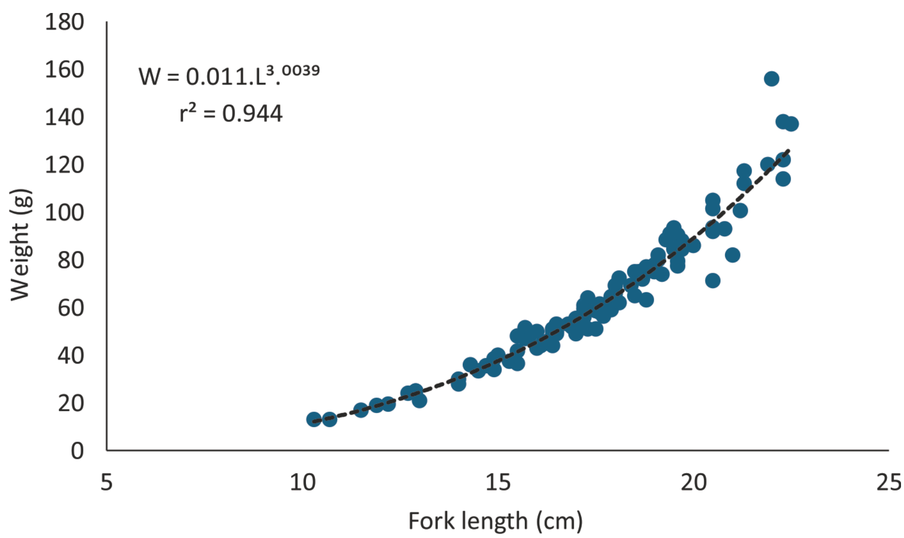


**Figure 2**

Length–weight relationship of the sampled *C. angorense*.

for males, females, and combined sexes did not significantly differ from 3.0 when compared with a *t*-test ($p > 0.05$). The VBGF equations were, respectively, estimated as follows for males, females, and the sexes combined: $L_t = 22.58\ (1–e^{–0.4596\ (t\ +\ 0.647)})$, $L_t = 27.43\ (1–e^{–0.3285\ (t\ +\ 0.954)})$, and $L_t = 32.64\ (1–e^{–0.109\ (t\ +\ 1.870)})$. Differences in growth parameters were observed between the sexes, and as a result, $L_\infty$ was found to be greater in females compared to males (27.43 vs 22.58, respectively). The growth coefficient *K*, which is proportional to the rate at which fish reach $L_\infty$, was greater in males (0.4596) compared to females (0.3285). There were no significant differences in expected lengths and observed lengths between males and females (Student's *t*-test, $t = 0.58$; d.f. = 101; $p > 0.05$).

Mean CF values ranged from 1.10 to 1.22 for both sexes with a mean (±SD) of 1.12 ± 0.09 (Table 1). The monthly mean CF values for males and females ranged from 1.05 to 1.14 (mean; 1.09 ± 0.07) and 0.80 to 1.19 (1.13 ± 0.12), respectively, indicating that the population is growing in good health. The monthly mean CF for both sexes showed remarkable consistency, with a slight variation noted in some months (Fig. 3). There were no significant differences in mean CF values between males and females in all age groups (Student's *t* test, $p > 0.05$).

### 3.3. Gonadal development and GSI

Maturity of ovaries exhibited monthly variations throughout the year. The mean GSI values varied from 2.56 to 13.34 in females and from 1.28 to 3.58 in males, with overall higher values in females than in males. Monthly fluctuations were observed in GSI values for both sexes, with the peak occurring in March (Fig. 4), followed by a decline in June. Besides a few minor discrepancies, the general pattern remained consistent across both sexes. Ripe and spent fish ovaries were



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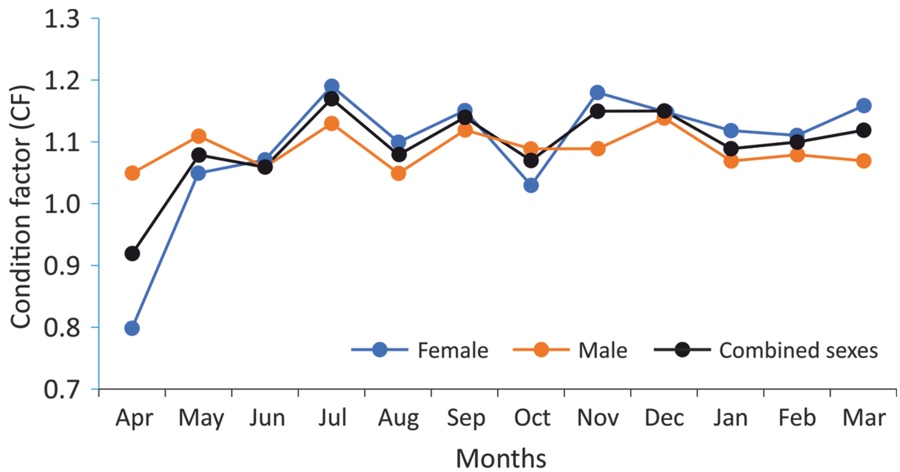


**Figure 3**

Monthly variations in CF (mean ± SD) of *C. angorense*. CF, condition factor; SD, standard deviation.

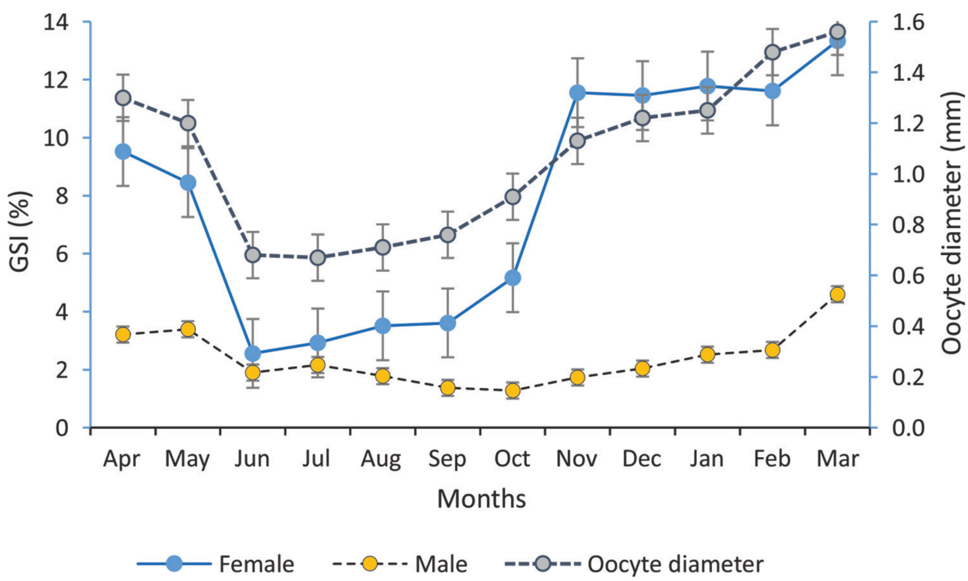


**Figure 4**

Monthly variations in GSI and oocyte diameter values with SD of *C. angorense*. GSI, Gonadosomatic Index; SD, standard deviation.

observed from March to June in this study. These results show that spawning occurred from March (GSI = 13.34) to June (GSI = 2.56). Following spawning, a quiescent phase of approximately 5 months (June–October) was observed, characterized by stable GSI values.

### 3.4. Size at first sexual maturity

The smallest TL is 11.4 cm and the largest is 24.0 cm (mean 19.2 cm ± 2.88 cm) in females. In male individuals, the smallest TL recorded is 11.8 cm and the largest is 24.1 cm (mean 18.6 cm ± 2.54 cm). The smallest mature female captured was 16.1 cm TL (34 g total weight) and the smallest mature male was 13.3 cm TL (19.5 g total weight). Female *C. angorense* attained sexual maturity at sizes very similar to those of males. The maturity ogives showed that 50% of females and males were sexually mature at TLs of 16.0 cm and 14.0 cm, respectively (Fig. 5). The observed difference in mean sexual maturity length ($L_m$) between the two sexes was not significant ($\chi^2 = 0.03$; $p > 0.05$). The first spawning age was three for females and two for males.

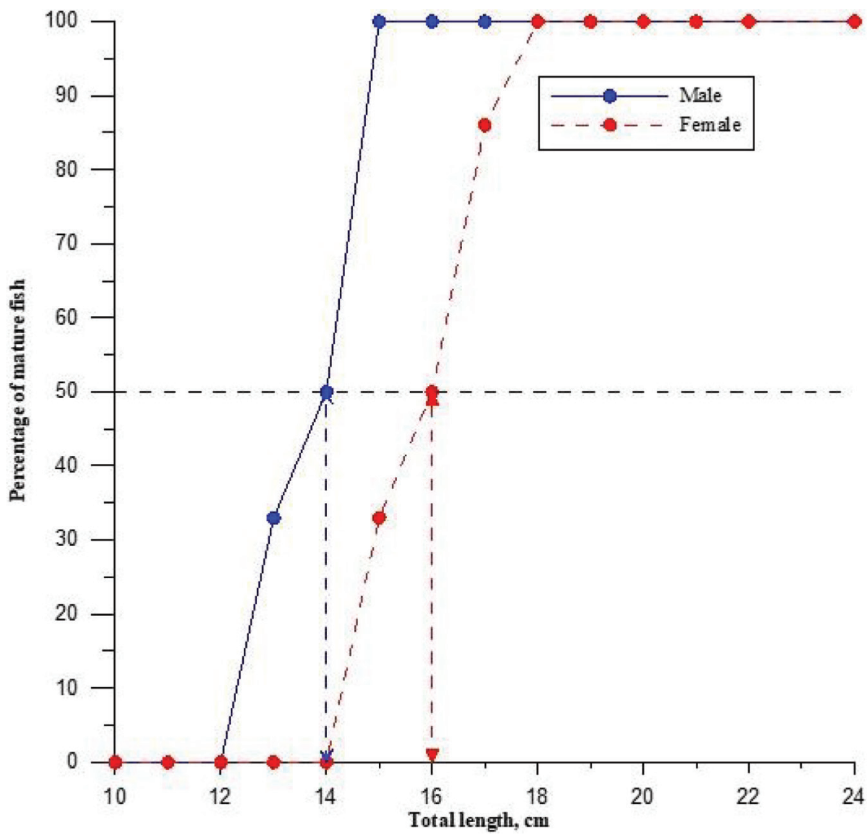


**Figure 5**

Ogive of first maturity for females and males of *C. angorense*.

### 3.5. Fecundity

The number of oocytes of 19 females at maturity stages IV and V ranged from 1015 (16 cm TL and 27 g body weight) to 10 664 (23.5 cm TL and 138 g body weight), while the mean absolute fecundity was 5130 ± 3246. The value of relative fecundity was 256 ± 141 oocytes $cm^{-1}$ of length (range 62–498 oocytes $cm^{-1}$) and 59 ± 21 oocytes $g^{-1}$ of total body weight (range 11–95 oocytes $g^{-1}$). No significant differences were found in the oocyte size between different parts of the ovaries ($F = 0.15$; d.f. = 2; $p = 0.85$). There were also no significant differences in the oocyte number between different parts of the ovaries ($F = 0.07$; d.f. = 2; $p = 0.92$). The relationships between fecundity and the four different variables (FL, *W*, GW, and *t*) are shown in Fig. 6. The strongest correlation was evident in the comparison of fecundity and GW ($R^2 = 0.9865$). The mean oocyte diameter was the smallest in June (0.68 mm) and the largest in March (1.56 mm). Oocyte diameters of mature females increased significantly from September to March (Fig. 4).

## 4. Discussion

Due to the lack of biological data on this endemic fish species, apart from the length–weight relationship study by Emiroğlu et al. (2020), we were unable to compare our findings with other studies. Although Hudson et al. (2014) reported 15-year-old *C. nasus* individuals, no fish older than 5 years were collected in this study. A wide age distribution within a population indicates sufficient food availability in the aquatic system (Nikolsky, 1963), good environmental conditions, and an absence of significant fishing pressure. This study considers that the widespread nature of recreational fishing in the region could negatively affect the age distribution and cause the loss of large individuals of this species. Additionally, changes in climate conditions (Ottersen et al., 2006), lower precipitation levels in the region (DSI, 2014), and irregular flow patterns in the river could have also contributed to the low average age. The sex ratio of male to female *C. angorense* in the Devrez River was found to be nearly equal (0.98:1.00), similar to the sex ratio of most freshwater fish species, which typically exhibit a ratio close to 1 (Nikolsky, 1963).

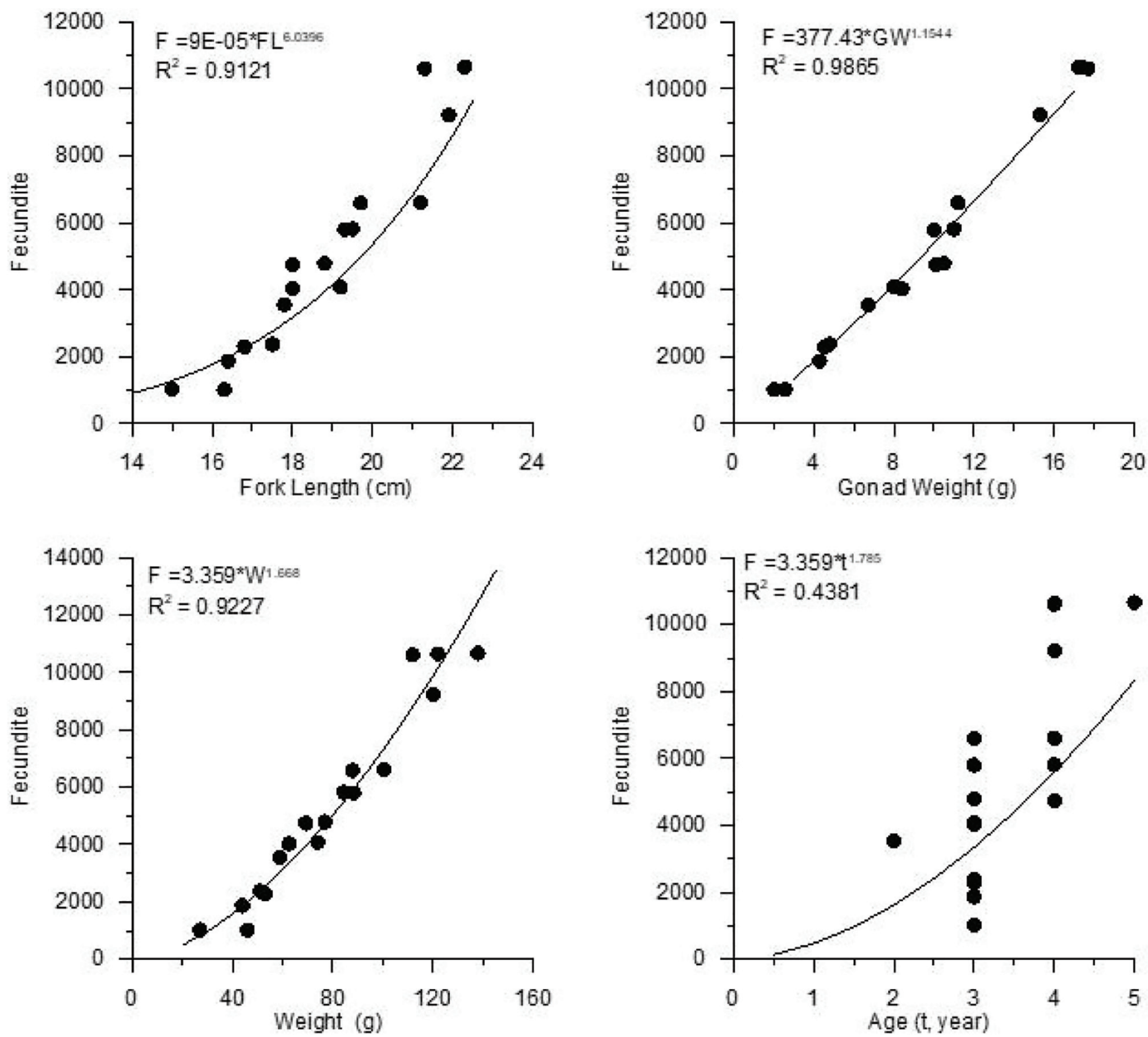


**Figure 6**

Relationship between fecundity and FL, GW, total weight, and the age of female *C. angorense*. FL, fork length; GW, gonad weight.

The body weight and TL range of *C. angorense* measured in this study were 13–156 g and 11.4–24.1 cm, respectively, which are similar to the findings for the same species (2.4–137 g and 6.8–24.7 cm) reported by Emiroğlu et al. (2020) from the Seydisuyu River basin, Türkiye. Differences in sampling time, sample size, types of length measured, and ecological features of the habitat might explain the variations in length and weight compositions.

Throughout this study, females were in better condition than the males. This might be due to the gonadal development of females. CF increased with age, while the monthly mean CF for both sexes remained generally consistent, with only slight variations in some months. According to Ünver and Tanyolaç (1999), a CF higher than 1 indicates a high feeding capacity of the ecosystem. It can be inferred that the feeding conditions in the Devrez River for *C. angorense*, which resulted in a mean CF exceeding 1 in both sexes, indicate physiological stability. Therefore, the CF data from this study suggest that this fish maintains a good nutritional status and capacity in the Devrez River.

The ‘*b*’ value explains the body shape (growth type) of the fish based on its environmental conditions (Bagenal, 1978). In this study, the length–weight relationship exponents for males indicate negative allometric growth ($b$ = 2.899), while for females ($b$ = 3.068) and combined sexes ($b$ = 3.004), growth is isometric. This means that while the bodies of females and combined sexes showing isometric growth morphologically resemble a torpedo, the bodies of males exhibiting negative allometric growth tend to become thinner. The variation in the exponents could be attributed to differences in sex, age, gonadal maturity, and species, as well as environmental factors across the study region.

In this species, the $L_\infty$ value was higher for females than for males; however, the growth coefficient ($K$) required to reach those lengths was lower in females than in males. This characteristic may represent sexual dimorphism in the genus *Chondrostoma*, as females tend to grow faster and live longer than males (Crivelli, 1981). Temperature, trophic status, hydrology, and genetic variations might cause differences in the estimated growth parameters (Gurbuz, 2017; Tempero et al., 2006). Due to natural causes such as predation and disease, fish rarely reach their asymptotic length in the wild (Biswas, 1993).

In this study, male individuals reached sexual maturity faster than females. As observed in most teleosts (Crivelli, 1981; Gürbüz, 2011; Smith & Walker, 2004), earlier maturity in males is associated with slower growth of somatic organs (Wootton, 1998). The age at sexual maturity of male and female fish was determined as 2 years and 3 years, respectively. The attainment of maturity might vary based on sex and latitude (Tempero et al., 2006) and might also be affected by environmental conditions such as temperature and feeding patterns. For the effective management and conservation of fish populations, the size at first maturation is essential. Additionally, during the spawning season, the breeding tubercles appeared in both sexes of *C. angorense* in this study.

The indication of spawning activity primarily relied on the presence of either ripe or spent females (Smith & Walker, 2004). Monthly fluctuations in GSI values were noted for both sexes, with a peak in March (see Fig. 4) and a subsequent decline in June, coinciding with spawning activity in most *C. angorense* individuals. The slight differences in the spawning period are thought to be related to the fish species and the ecological conditions of the water system they inhabit (Nikolsky, 1963). The spawning period of *C. angorense* was determined to occur from March to June, based on GSI values, gonadal development stages, and oocyte diameters. Based on monthly variations in these parameters, *C. angorense* is considered an asynchronous, single-spawning species.

Fecundity is crucial for the sustainability of fish populations. In this study, fecundity values were positively correlated with fish length, weight, GW, and age (see Fig. 6). It appears that GW may be a more reliable indicator for estimating the fecundity of *C. angorense*. Factors such as fish age, species, length, weight, health, oocyte diameter, population density, and various environmental variables influencing the trophic status of a water system may be correlated with fecundity values (Nikolsky, 1963).

The mean oocyte diameter of *C. angorense* was 1.27 mm (range: 0.90–1.57 mm). Oocyte diameter in fish may vary due to factors such as fish size, maturation stage, and different parts of the ovary, as reported in other species (Johnston & Leggett, 2002).

## 5. Conclusion

Despite their significant role in biodiversity, there is often limited information available regarding the biological characteristics of many endemic fish species in Türkiye. This is the first detailed study on the biology of endemic *C. angorense*. This study employed a multidisciplinary approach to better understand the growth and reproductive biology of *C. angorense* in the Devrez River, Türkiye. Locally, this species is of some commercial importance to recreational fisheries. It should be prohibited to catch fish smaller than the $L_{50}$ (14 cm for males and 16 cm for females), and fishing should not be allowed during the spawning seasons to ensure sustainable management. Adjusting the minimum catch size to be larger than the size at first sexual maturity would allow the species to reproduce at least once before being caught.

Although nearly half of Türkiye's freshwater ichthyofauna, comprising 409 species, are endemic (Çiçek et al., 2018), endemic fish species face significant threats from anthropogenic factors such as dam construction, pollution, habitat degradation, as well as invasive species and drought (Fricke et al., 2007). Both *C. angorense* and other fish species in the Devrez River are under threat due to drought- and human-induced factors such as dams and habitat degradation. The Devrez Kızlaryolu Dam, currently under construction on the Devrez River, is thought to pose the most significant threat to *C. angorense* in the future, similar to other rheophilic fishes living here, due to the considered insufficiency of reserved water volume for aquatic life (DSI, 2014). Even though the critical abstraction level for rivers is 20%, with a 30% abstraction allowed for the least sensitive rivers at the lowest level of protection (Acreman & Ferguson, 2010), the abstraction in the Devrez River will exceed

30%. Furthermore, the planned environmental flow rate (0.26 $m^3 \cdot s^{-1}$) for the Devrez River is significantly below the current flow rate (4.081 $m^3 \cdot s^{-1}$) (DSI, 2014). To protect aquatic life, it is vital to establish the appropriate environmental flow rate for the river. Regular monitoring of the river ecosystem is, therefore, needed to maintain the health of endemic and native fish species. Considering that the river's fish species are predominantly rheophilic, which means they prefer or inhabit fast and clear-flowing waters, the importance of taking proper measures is more apparent. The findings of this study can serve as foundational data for managing fisheries and conserving species, given the lack of existing data on the growth and reproductive biology of *C. angorense*.

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