

Some Reproduction Characteristics of *Chalcalburnus mossulensis* (Heckel, 1843) Inhabiting the Karasu River (Erzurum, Turkey)

Ayhan YILDIRIM^{1,*}, Halil İbrahim HALILOĞLU², Orhan ERDOĞAN², Mustafa TÜRKMEN³

¹Atatürk University, İspir Hamza Polat Vocational School, İspir, Erzurum - TURKEY

²Atatürk University, Faculty of Agriculture, Department of Fisheries, Erzurum - TURKEY

³Mustafa Kemal University, Faculty of Fisheries, Hatay - TURKEY

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Abstract: Some reproduction characteristics of *Chalcalburnus mossulensis* from the Aşkale region of the Karasu River, including sex ratio, spawning season, first maturity, and fecundity, were investigated between November 1995 and October 1997. The male to female ratio was 1:1.08, which was not significantly different from 1:1. Fecundity ranged from 3012 to 11,417 ova per female. There were significant correlations between fecundity, and fork length, total weight, age, and gonad weight. The length and age at first maturity for the males and females were 1.26 years and 9.24 cm, and 1.81 years and 9.65 cm, respectively. The spawning period was from June to August, when the water temperature reached 15 °C.

Key Words: *Chalcalburnus mossulensis*, fecundity, maturity, spawning season, Karasu River

Karasu Nehri Aşkale Mevkiinde Yaşayan *Chalcalburnus mossulensis* (Heckel, 1843)'in Bazı Üreme Özellikleri

Özet: Kasım 1995 ile Ekim 1997 tarihleri arasında Karasu Nehri Aşkale mevkiinden yakalanan *Chalcalburnus mossulensis*'in cinsiyet oranı, üreme mevsimi, ilk olgunluk, yumurta verimi gibi üreme özellikleri araştırılmıştır. Erkek dişi oranı 1:1,08 ve istatistik olarak önemsiz bulunmuştur. Yumurta verimi 3012 ile 11.417 yumurta/birey arasında değişmiştir. Yumurta verimi ile boy, ağırlık, gonat ağırlığı ve yaş arasında korelasyonlar bulunmuştur. İlk olgunluk yaşı ve boyu da, erkek ve dişiler için sırasıyla, 1,26 yıl, 9,24 cm ve 1,81 yıl, 9,65 cm olarak hesaplanmıştır. Üreme su sıcaklığının 15 °C ulaştığı Haziran ile Ağustos arasında meydana gelmiştir.

Anahtar Sözcükler: *Chalcalburnus mossulensis*, yumurta verimi, olgunluk, üreme mevsimi, Karasu Nehri

Introduction

Chalcalburnus mossulensis (*C. mossulensis*) is a species of the genus *Chalcalburnus* of Cyprinidae (Kuru, 1975). The genus *Chalcalburnus* is widely distributed in southern Iran, Lake Van, the Aral Sea, and the Black Sea Basin. *Chalcalburnus* species, including *C. mossulensis*, *C. tarichi*, *C. chalcoides*, and *C. sellal*, have been recorded in the inland waters of Turkey (Geldiay and Balık, 1996). *C. mossulensis* is widely distributed in the Karasu River, the Euphrates Basin, and in eastern and southeastern Turkey (Kuru, 1975). The taxonomic and systematic characteristics of *C. mossulensis* have been adequately

studied (Balık, 1975; Kuru, 1975; Erk'akan, 1983), but there is very limited information available concerning life history characteristics (Ergene, 1993; Türkmen and Akyurt, 2000; Yıldırım et al., 2003). Moreover, we found only one article about the reproductive characteristics of *C. mossulensis* (Şen, 1985).

In this study, we attempted to describe (1) the age and length at first maturity, (2) gonadal development and spawning season, and (3) fecundity and relationships between fecundity, and length, weight, age, and gonad weight of *Chalcalburnus mossulensis* from the Karasu River, Erzurum, Turkey.

* E-mail: ayhanyildirim@yahoo.com

Materials and Methods

The study area was the upper part of the Karasu River, located in the East Anatolia region of Turkey (lat 39°56'16"N, long 40°45'33"E) (Figure 1). The water source is snowmelt and rain. The bottom structure consists of sand, stone, and silt. It is about 15 km long, 10-30 m wide, and 50-220 cm deep. The recorded air and water temperature during the 24-month study period varied from -25 °C to +29 °C and from -1.5 °C to +27 °C, respectively. The Karasu River started freezing in the middle of December and became ice-free by early March. Discharge ranged from 4.90 (October) to 61.8 (May) m³/s (EİE, 1996). The river runs through several locations, such as Erzurum, Ilica, and Aşkale. The human populations and distances to the sampling area from those locations are 250,000 and 60 km, 14,000 and 50 km, and 15,000 and 5 km, respectively. Furthermore, there are several industrial activities, such as cement production, textile dyeing, and sugar beet production, at the upper part of the study area.

Individuals from the Karasu River were caught on a monthly basis from November 1995 to October 1997 with cast nets (12 x 12 mm mesh size). Specimens were placed on ice and brought to the laboratory where they were kept in a freezer at -10 °C for future analysis. Prior to dissection, all fish were thawed, rinsed, and blotted dry; then they were measured (fork length, mm), and

weighed (g). After dissection, sex and maturity were determined by macroscopic or microscopic examination of the gonads, which were also weighed (GW). The ovaries were then placed in Gilson fluid (Baganel and Braum, 1978) and the stages of maturation were classified as follows: stage 1: immature; stage 2: developing; stage 3: ripe; stage 4: spawning; stage 5: spent (King, 1995). The ratio of males to females was tested with the chi-square test (Zar, 1984). The reproductive period was determined using the

$$\text{gonadosomatic index (GSI), calculated as } GSI = \frac{Wg}{W} \times 100,$$

where W is total weight (g) and Wg is gonad weight (g) (Anderson and Gutreuter, 1983).

The length and age at first maturity were estimated for both sexes caught from April to July. To estimate the mean length and age of 50% maturity, a logistic function was fitted to the proportion of the mature individuals in size class by using non-linear regression. The following functions were used:

$$P = \frac{1}{[1 + \exp(-r(L - L_m))]}$$
 for length,

$$P = \frac{1}{[1 + \exp(-r(T - T_m))]}$$

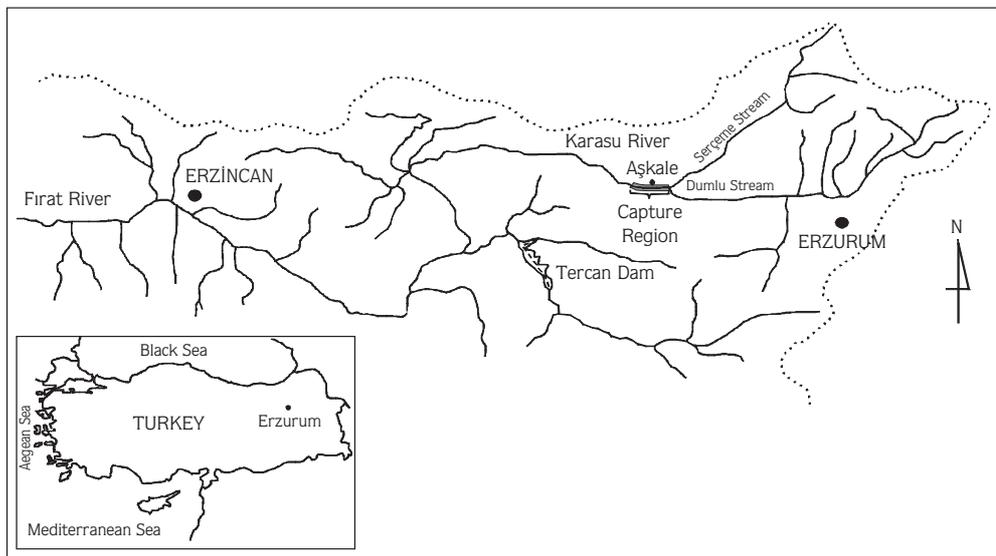


Figure 1. Upper part of the Euphrates Basin in Turkey, showing the region of the sample site in the Karasu River.

for age, where P is the mature proportion in each size class, r is a parameter controlling the shape of the curve, and L_m or T_m is the size at 50% maturity. T_m or $L_m = a/r$, where a is the intercept (Saila et al., 1988). The point differences between first maturity length and age of males and females were tested with a regression approach by comparing the slopes and intercepts of 2 equations for both sexes, and the following null hypotheses were tested together: $H_0: \beta_1 = \beta_2$ and $H_0: \alpha_1 = \alpha_2$ (Bek, 1986).

Fecundity was measured in females captured prior to the reproductive period (in May and June) and preserved in Gilson's fluid. It was estimated by gravimetric method, weighing all the eggs in the ovary and counting 3 subsamples of eggs of equal weight from the front, middle, and back of the ovary (Bagenal and Braum, 1978). Linear, logarithmic, exponential, power, inverse, compound, and growth models were used to determine what equation best described the relationships between fecundity, and length, weight, ovary weight, and age. SPSS (9.0 for Windows) was used to carry out these procedures.

Scales, which were cycloid, were removed from the left side of the fish just before the dorsal pinnalis, above the lateral line for age determination, and several scales from each fish were cleaned with 5% NaOH. Ages were determined with a microprojector (Ken-a-Vision model) after the scales were placed between slides. The first formation annuli of the new-born fish started on the outer edges of the scales in February of the year following their birth, i.e. in the 9th/10th month of the first

year of life. The annuli were almost completed by April and were fully completed by the end of May, i.e. the 12th month. Thus, this species up to its 9th/10th month is considered to belong to the age class 0. Between the 10th and 21st months, when the second year-ring begins to form on the outer edge of the scale, it is considered to belong to age class 1, and so on (Table 1). The relative ages recorded by Chugunova (1959) are in agreement with this. Williams and Bedford (1973) also consider fish between birth and 9 months to belong to age class 0, from 10-22 months to class 1, from 22-34 months to age class 2, and so on.

Table 1. Correspondence between age classes and real ages, and numbers of annuli in the scales of *C. mossulensis* from the Karasu River, Erzurum, Turkey.

Age-class	1	2	3	4	5	6
Months old	10-21	22-33	34-45	46-57	58-69	70-81
Year-ring	1	2	3	4	5	6

Results and Discussion

In all, 850 fish were collected during the sampling period, of which 409 (48.1%) were male and 441 (51.9%) were female. The male to female ratio was 1:1, except in age classes 2 and 5 (Table 2). It is well known that the sex ratio for most species is close to 1:1 (Nikolsky, 1963). Although the number of males was more than the number of females in the younger age classes, there were more females than males in the older

Table 2. Age and sex composition of *C. mossulensis* from the Karasu River, Erzurum, Turkey.

Age Class	Male		Female		M:F Ratio	χ^2 value
	N	N%	N	N%		
1	20	2.35	20	2.35	1:1.00	0.000
2	83	9.76	53	6.24	1:0.64	6.618*
3	258	30.35	264	31.06	1:1.02	0.069
4	36	4.24	67	7.88	1:1.86	0.330
5	9	1.06	24	2.82	1:2.67	6.818*
6	3	0.35	9	1.06	1:3.00	3.000
7	-	-	4	0.47	-	-
Total population	409	48.12	441	51.88	1:1.08	1.205

* Difference between sexes was statistically significant ($P < 0.05$)

age classes (Table 2), which is in good agreement with Akgül (1980), Ünal et al. (1996), and Sarı and Arabacı (1997) for the genus *Chalcalburnus*. It is reported that in freshwater fish the ability of hatching out is generally higher in males than in females, but in upper age classes, the number of males becomes lower and lower, and the number of females becomes quite dominant in a population (Nikolsky, 1963).

The age and length at first maturity (T_{50} and L_{50}) were estimated to be 1.26 years and 9.24 cm FL, and 1.81 years and 9.65 cm FL, respectively (Figures 2 and 3). The age and length for maturation range and full maturity are shown in Table 3. The age at first maturity we observed was in fairly good agreement with Akgül (1980), Şen (1985), Çetinkaya and Öksüz (1996), and Sarı and Arabacı (1997), all of whom found that age at first maturity for the genus *Chalcalburnus* was 2 years, but not with Ünal et al. (1996) and Elp (1996), who

determined that it was age 3 years for some other species of *Chalcalburnus*. The length at first maturity was slightly lower than that reported by Çetinkaya and Öksüz (1996) and Elp (1996). Those differences can be attributed to species and environmental factors, such as temperature, the quantity and quality of food, and the water systems in which the fish lived.

The GSI of males and females for both study years (Figure 4) fluctuated and reached a peak in June, and reproduction during both years occurred from June to August, when water temperature reached 15 °C. Several studies suggested that the spawning season of the genus *Chalcalburnus* occurred from April to July (Akgül, 1980; Şen, 1985; Danulat and Selçuk, 1992; Çetinkaya et al., 1995; Çetinkaya and Öksüz, 1996; Elp, 1996; Ünal et al., 1996; Sarı and Arabacı, 1997) (Table 4). The spawning season of fish may vary with respect to the ecological characteristics of different water systems, such

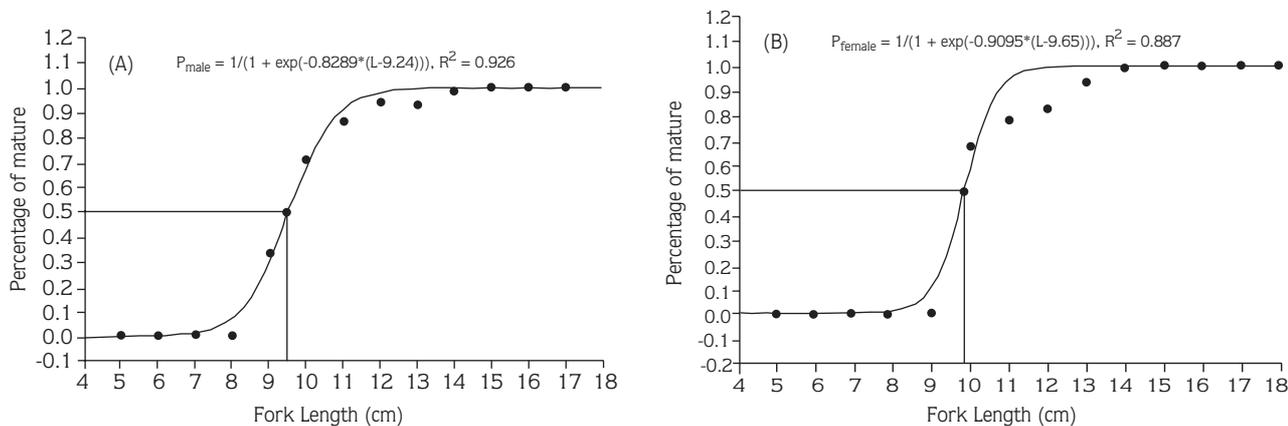


Figure 2. Length at first maturity for (A) males and (B) females of *C. mossulensis* from the Karasu River, Erzurum, Turkey.

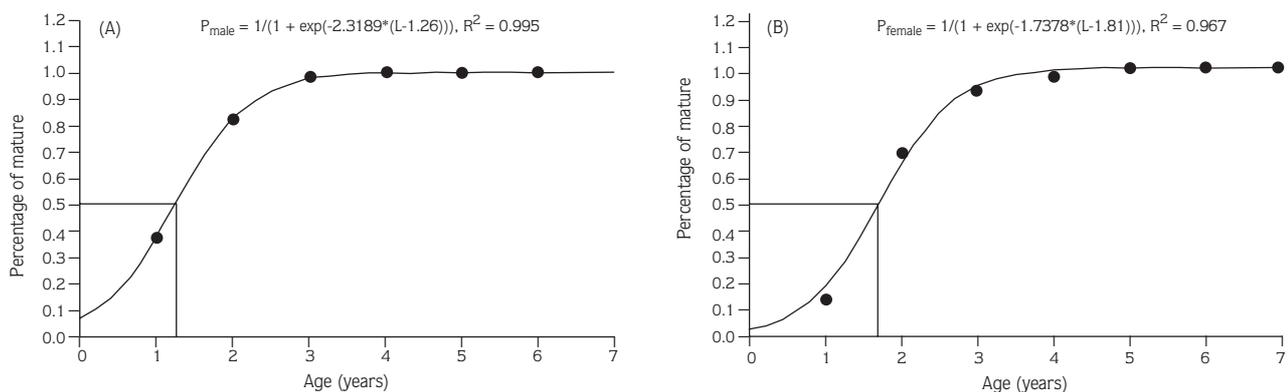


Figure 3. Age at first maturity for (A) males and (B) females of *C. mossulensis* from the Karasu River, Erzurum, Turkey.

Table 3. Equations of length (cm) and age (year) at first maturity (L_{50} or T_{50}), full maturity (L_{95} or T_{95}), and maturation range (L_{25-75} or T_{25-75}) as a function of sex of *C. mossulensis* from the Karasu River, Erzurum, Turkey.

Sex	Equation	L_{25-75} (cm)	L_{25-75} (cm)	R2
Male	$P = 1/(1 + \exp[-0.8289*(L-9.24)])$	7.92-10.56	12.79	0.926
Female	$P = 1/(1 + \exp[-0.9090*(L-9.65)])$	8.44-10.85	12.88	0.887
		T_{25-75} (year)	T_{95} (year)	
Male	$P = 1/(1 + \exp[-2.3189*(T-1.26)])$	0.79-1.73	2.53	0.995
Female	$P = 1/(1 + \exp[-1.7378*(T-1.81)])$	1.17-2.44	3.54	0.967

Table 4. Some reproduction characteristics for different species of the genus *Chalcalburnus* from different populations.

Author(s)	Species	Study area	M:F ratio	Sex	Spawning age (age)	Spawning length (cm)	Spawning season	Fecundity
Akgül (1980)	<i>C. tarichi</i>	Van Lake	1:1.3	M + F	2		June-July	6785-14,519
Şen (1985)	<i>C. mossulensis</i>	Karakoçan, Kalecik Dam Lake	1:8.7	M + F	2		May-July	
Danulat and Selçuk (1992)	<i>C. tarichi</i>	Van Lake					April-July	
Çetinkaya et al. (1995)	<i>C. tarichi</i>	Van Lake					May-June	
Çetinkaya and Öksüz (1996)	<i>C. tarichi</i>	Van Lake	1.08:1	M + F	2	12-13	May-June	
Ünal et al. (1996)	<i>C. tarichi</i>	Van Lake		M + F	3		May-June	
Elp (1996)	<i>C. tarichi</i>	Van Lake	1:1.8	M + F	3	13.16	May-July	8745
Sarı and Arabacı (1997)	<i>C. tarichi</i>	Van Lake					May-July	1562-11,049
Present study	<i>C. mossulensis</i>	Karasu River	1:1.08	M F	2 2	9.24 9.65	June-Aug.	3012-11,417

as water temperature and photoperiod, which have major effects on gonad maturation and spawning season (Bagenal and Braum, 1978; Wootton, 1990). Moreover, Yıldırım and Aras (2000) reported that spawning season varied from year to year due to water temperature. Additionally, reproduction of *C. mossulensis* occurs once a year (Figure 4), like in other *Chalcalburnus* species (Çetinkaya and Öksüz, 1996; Elp, 1996; Sarı and Arabacı, 1997).

Fecundity was estimated from 57 females caught in May and June (Table 5). Fecundity varied from 3011 (age 2 years) eggs per female to 11,417 (age 7 years) eggs per female (Table 5), whereas previous reports ranged from 1562 to 14,519 in different populations of the genus *Chalcalburnus* (Akgül 1980; Elp, 1996; Sarı and Arabacı, 1997) (Table 4). Differences among the

populations can be attributed either to the effects of different environmental factors or to differences of species, since fecundity is affected by different environmental factors and may vary between different species (Nikolsky, 1963; Bagenal and Braum, 1978; Wootton, 1990). We determined that relations between fecundity, and length, total weight, ovary weight, and age were described by a power function (Figure 5), and R^2 values of the functions were somewhat strong, like in other cyprinid species (Yıldırım and Aras, 2000; Türkmen et al., 2001; Türkmen et al., 2002). According to R^2 values for fecundity, the strongest relationship was with total weight, followed by fork length, ovary weight, and age, and those results are in good agreement with those for some other cyprinid species (Türkmen et al., 2001; Erdoğan et al., 2002; Türkmen et al., 2002).

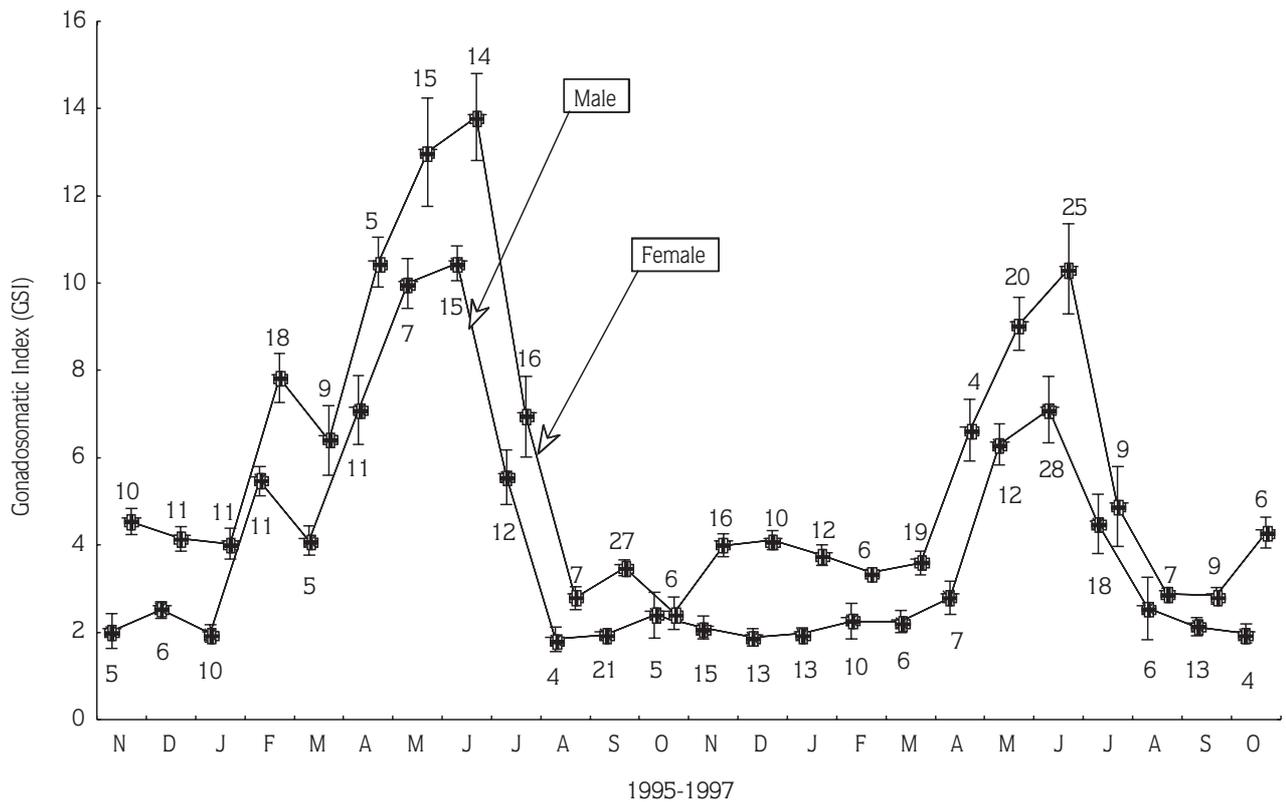


Figure 4. Annual cycle of the gonadosomatic index (mean ± SE) of sexes (Numbers at data points indicate the sample size for sexes) from the Karasu River, Erzurum, Turkey.

Table 5. The fecundity at different age classes of *C. mossulensis* from the Karasu River, Erzurum, Turkey.

Age	n	Fork Length*	Total Weight*	Fecundity*	Relative Fecundity*
2	6	12.02 ± 0.23	20.11 ± 0.56	3012 ± 289	149,329 ± 11,944
3	35	13.48 ± 0.18	28.27 ± 1.28	4587 ± 376	161,340 ± 10,793
4	9	15.01 ± 0.31	37.72 ± 1.56	6769 ± 724	179,299 ± 17,531
5	5	16.76 ± 0.28	55.91 ± 5.43	8088 ± 672	148,612 ± 14,311
6	1	18.50	79.50	10458	131,547
7	1	17.80	76.00	11417	150,224
Mean	57	14.02 ± 0.23	33.07 ± 1.88	5296 ± 349	161,077 ± 7398

* mean ± SE

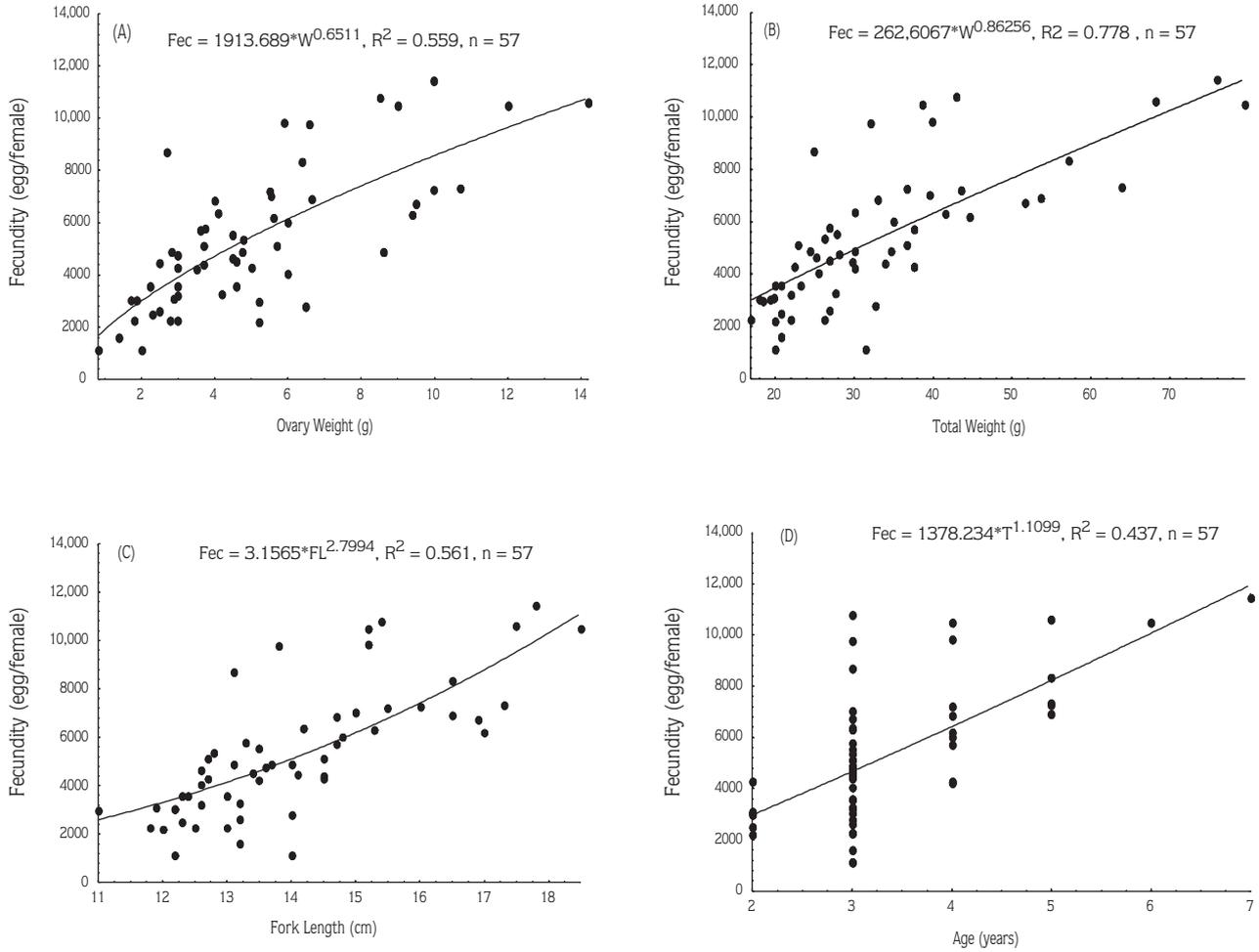


Figure 5. Relationships between fecundity and the ovary weight (A), weight (B), length (C), and age (D) of *C. mossulensis* from the Karasu River, Erzurum, Turkey.

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