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Source: Folia Zoologica, 60(2) : 153-158

Published By: Institute of Vertebrate Biology, Czech Academy of Sciences

URL: https://doi.org/10.25225/fozo.v60.i2.a9.2011

Folia Zool. – 60 (2): 153–158 (2011)

Life history and other biological traits of the trout barb *Capoeta trutta* in the River Meymeh (western Iran)

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Received 23 April 2010; Accepted 15 September 2010

Abstract. The trout barb *Capoeta trutta* is native to the Middle East only and little is known of its life-history in Iranian waters. Life history characteristics were examined in 366 specimens collected from the River Meymeh (western Iran) monthly during the reproductive seasons (March-May) of 2008 and 2009. Observed maximum age was 6+ years in both sexes, sex ratio (male : female) was 1 : 1.35, and length-weight relationships were $TL = 0.0266TW^{2.7134}$ (males), $TL = 0.0258TW^{2.7251}$ (females), and $TL = 0.026TW^{2.7217}$ (entire population). Mean egg diameter (*ED*) was 1.61 (± 0.03 *SE*), ranging from 1.6 to 1.9 mm. Mean absolute (*AF*) and relative fecundity (*RF*) were 7594 (± 283.04 *SE*) eggs/female, and 70 (± 241.86 *SE*) eggs·g^{-1} body weight, respectively. *AF* and *ED* were found to increase significantly with increasing fish size, whereas *RF* decreased significantly with both fish *TL* and weight. Simplified von Bertalanffy growth estimates were also calculated.

Key words: age, von Bertalanffy growth, egg diameter, reproduction, fecundity

Introduction

The trout barb *C. trutta* (Heckel, 1843) is a cyprinid species native to the Middle East (Iran, Iraq, Syria and Turkey), encompassing much of the Iranian part of Tigris-Euphrates basin, including most tributaries of the River Karoun (Abdoli 2000). Compared with other species of Cyprinidae in western Iran, many aspects of the trout barb biology remain unstudied. Abdoli (2000) provided some information on the morphology and biology of this species, derived from a limited number of specimens. According to the IUCN classification, the species is listed in the category "DD" (data deficient). However, this species does not appear in need of conservation. Populations of this species are found in some lakes and rivers of Iraq (Coad 1991) and Turkey, where the species has received some studies (Polat 1987, Ünlü 1991, Gül et al. 1996, Kalkan 2008). Differences are known to occur in growth and reproductive features between the populations of same species living in different regions, and these differences are fundamental for understanding the species' life history patterns. In light of the climatic differences between the tributaries of Tigris-Euphrates basin, we hypothesized that the populations of this species inhabiting Iranian tributaries differ from those of the Turkey and Iraq in life history traits. Therefore, the aim of the present paper is to present the first detailed data on the growth and life-history traits of trout barb in the River Meymeh, which is one of the Iranian tributaries of Tigris-Euphrates basin.

Material and Methods

The River Meymeh (Table 1) is situated in the western Iranian province of South Ilam (latitude: 32°44′ E; longitude: 47°09′ N, altitude: 208-2500 m) Afshin (1994). The reproductive period of the trout barb in eastern Iran is believed to extend from March to May (Abdoli 2000), so specimens were collected from middle parts of the river during these months in 2008 and 2009 using a small beach seine (30 m length, 2 m depth, knot to knot mesh size = 3 mm). All fish specimens were immediately preserved in 10 % formaldehyde solution

Table 1. *Average of some environmental factors (min-max.) for the River Meymeh (western Iran) (Cheraghi et al. 2007).*

Characteristics	$\bar{x}$ (minimum-maximum)
Length km	130
Mean gradient	1.6 %
Water discharge m^3/s	2.08 (0.12-44.19)
Dissolved oxygen (mg/l)	8.94 (7.41-10.24)
pH	7.47 (6.8-8.13)
Electrical conductivity (ms/cm)	10.23 (1.12-114.89)
Total dissolved solids mg/l	42.54 (11.35-147.74)
HCO_3^- mg/l	2.45 (1.1-4.7)
SO_4^{--} mg/l	25.75 (9.51-82.60)
Ca^{++} mg/l	27.62 (9.50-54.50)

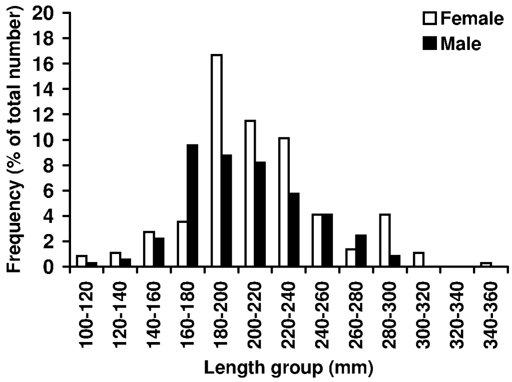

Fig. 1. *Total length (mm) frequency of males and females of trout barb* C. trutta *in the River Meymeh (western Iran).*

for subsequent examination in the laboratory.

In the laboratory, all 366 specimens sampled were measured for total length (*TL*) as well as for total body (*TW*) and gonad weight (0.01 g). Age was determined from opercula taken from both sides, which were validated with scale and cleithra readings. Opercula were reviewed for banding patterns three times, each time by a different person using a binocular microscope under reflected light at 20-30×.

The relationship between the *TL* and *TW* was determined by fitting the data with the equation: $TW = aTL^b$, where a is the intercept and b is the slope (coefficient of allometry) as per Pauly (1984). Age-specific *TLs* were estimated using the equation $TL_i = S_iS_c^{-1}(TL_c - c) + c$, where TL_i is *TL* of the fish at age i, TL_c is the *TL* of the fish at capture, S_i is the largest radius of the operculum at age i, S_c is the largest radius of the operculum at capture and c is the intercept of the regression of *TL* against operculum radii (Johal et al. 2001). The adopted growth model was the specialized von Bertalanffy growth function (*VBGF*), whose expression is: $L_t = L_\infty(1 - e^{-k(t - to)})$ where L_∞ is the predicted asymptotic length, L_t is the size at age t, k is the instantaneous growth coefficient, and t_o is the point at which the von Bertalanffy curve intersects the age axis. The parameters were estimated using the method of Ford-Walford (Everhart & Youngs 1975) and phi-prime (Φ') was used to study overall growth performance (Munro & Pauly 1983): $\Phi' = \ln k + 2\ln L_\infty$.

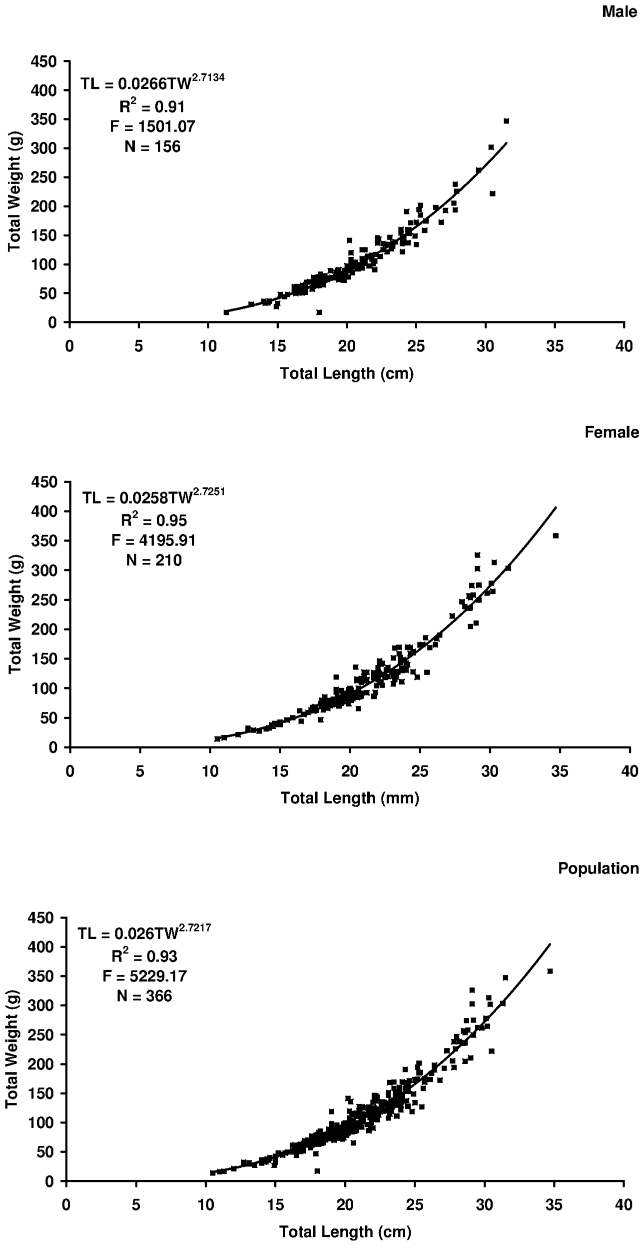

Fig. 2. *Relative growth curves (total length-total weight) of males, females and population of trout barb* C. trutta *in the River Meymeh (western Iran).*

Sex was determined by visual examination of the gonad tissue either by eye or with the aid of a stereomicroscope. Gonadosomatic index (*GSI % = [gonad weight ÷ TW] × 100*) was calculated for each fish and all the mean values was calculated for each sampling date. In order to estimate absolute (*AF*) and relative (*RF*) fecundities, the ovaries of 149 ripe females with maturity stage IV were used. Ovaries were removed, weighed and then placed in Gilson's fluid for 3-4 days to harden eggs and dissolve ovarian membranes. *AF* was estimated using the gravimetric method, using three pieces removed from anterior, medial and posterior of the ovary. *RF* was calculated as *RF = AF/TW* (Bagenal & Tesch 1978). Mean egg diameter was examined by measuring 25-30 eggs taken randomly from pieces of the ovary of 149 ripe females used for fecundity determination. Measurements were made to the nearest 0.05 mm with an ocular micrometer microscope.

Analysis of covariance (ANCOVA) was performed to test significance differences in weight-length relationships between sexes. The overall sex ratio was assessed using the chi-square test (Zar 1984). Comparison of *GSI* values between sexes was carried out by analysis of variance (ANOVA). Statistical analyses were performed with the SPSS 11.5 software package and a significant level of 0.05 was accepted.

Results

In the 366 specimens of the trout barb captured, maximum age in both sexes was age 6+, with males ranging from 11.3 to 31.5 cm *TL* and 16.93 to 347.10 g *TW* and females ranging from 10.5 to 34.7 cm *TL* and 13.91 to 358.42 g *TW*. The most frequent size class in the samples was 150-180 mm for males and 180-200 mm for females (Fig. 1). Males were so scare in the length classes > 300 mm *TL*. The overall sex ratio was 1 : 1.35, with females significantly more prevalent than males ($\chi^2 = 7.97$, $P < 0.05$).

Observed length-at-age differed between the sexes (Table 1), with females were longer and heavier than males (ANCOVA, $F_{TL} = 74.21$, $F_{TW} = 92.01$, $P < 0.05$). Length-weight relationships were significant with a high regression coefficient (Fig. 2). The coefficients of the calculated regressions were significantly different between each of considered groups. The slope *b* values indicate a negative pattern of allometric growth (*t*-test, $t_{male} = 6.82$, $t_{female} = 8.02$, $t_{population} = 7.89$, $P < 0.05$). From the mean back calculated *TL* values for each age group (Table 2), the von Bertalanffy growth model (Table 3) suggests that males grow faster than females ($k_{female} < k_{male}$), whereas asymptotic total length was greater for females than for males.

GSI was significantly lower in males than in females (ANOVA, $F_{1, 365} = 14.10$, $P < 0.05$), with the highest mean value observed in April for both sexes: 4.667 ± 0.51 (*SE*) and 6.595 ± 0.99 (*SE*) for males and 7.602 ± 0.63

Table 2. *Mean observed (MO) and mean back-calculated (MBC) total lengths (cm) ± S.D. at age for males, females and population of trout barb* C. trutta *in the River Meymeh (western Iran).*

Age (years)	0+	1+	2+	3+	4+	5+	6+
				Male			
MO TL(cm)	-	13.89 ± 1.20	17.35 ± 0.80	19.94 ± 0.84	23.46 ± 1.24	28.03 ± 1.48	31.05 ± 0.00
MBC TL(cm)	6.57 ± 1.24	12.85 ± 1.02	16.01 ± 0.79	17.98 ± 0.77	21.79 ± 1.01	26.27 ± 1.22	28.75 ± 0.00
				Female			
MO TL(cm)	-	14.09 ± 1.65	18.67 ± 0.71	21.04 ± 0.78	24.02 ± 1.01	28.91 ± 0.75	32.00 ± 2.40
MBC TL(cm)	7.55 ± 1.35	13.82 ± 1.40	17.99 ± 0.59	21.39 ± 0.72	23.41 ± 0.87	27.02 ± 0.62	31.31 ± 1.84
				Population			
MO TL(cm)	-	14.03 ± 1.51	18.13 ± 0.99	20.55 ± 0.97	23.75 ± 1.16	28.60 ± 1.13	32.50 ± 1.91
MBC TL(cm)	7.03 ± 1.31	13.39 ± 1.52	16.98 ± 0.64	19.68 ± 0.75	22.61 ± 0.94	26.59 ± 1.01	30.02 ± 1.82

Table 3. *Estimates of von Bertalanffy length-at-age growth parameters for males, females and population of trout barb* C. trutta *in the River Meymeh (western Iran).*

Sex	L_∞ (mm)	k (year^{-1})	t_o (year)	φ'
Male	45.86	0.14	–1.15	5.68
Female	50.79	0.13	–1.45	5.81
Population	48.60	0.13	–1.28	5.72

and 7.934 ± 0.53 (*SE*) for females, in 2008 and 2009 respectively. Spawning was first observed in May, so the reproductive period for this species in the River Meymeh is March to May.

Mean egg size was 1.61 (± 0.03 *SE*), with the majority of oocytes ranging from 1.6 to 1.9 mm (Fig. 3). Egg diameter was positively correlated with both *TL* and *TW* (Fig. 4). Minimum absolute fecundity (*AF*) was

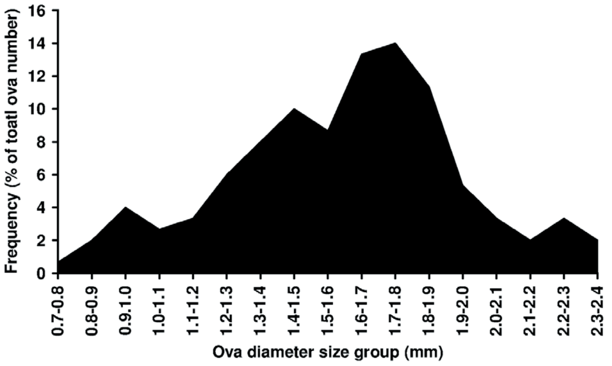

Fig. 3. *Size frequency distribution of the oocyte diameter of female trout barb* C. trutta *in the River Meymeh (western Iran).*

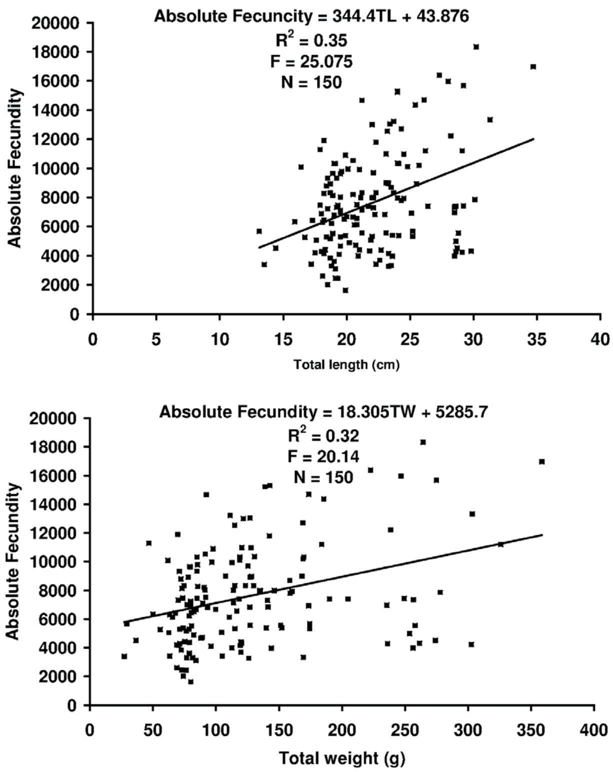

Fig. 5. *Relationship between absolute fecundity and fish total length (mm) and total weight (g) of female trout barb* C. trutta *in the River Meymeh (western Iran).*

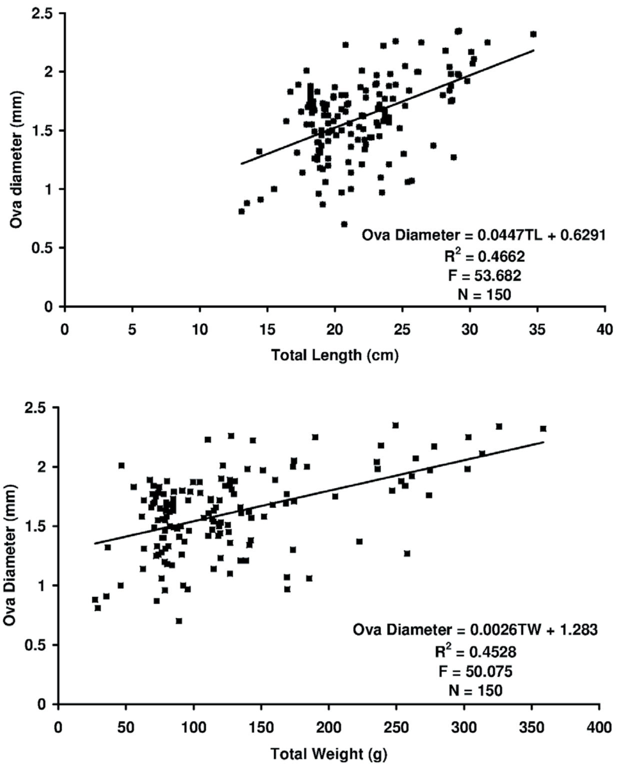

Fig. 4. *Relationship between ova diameter and total length (mm) and total weight (g) of female trout barb* C. trutta *in the River Meymeh (western Iran).*

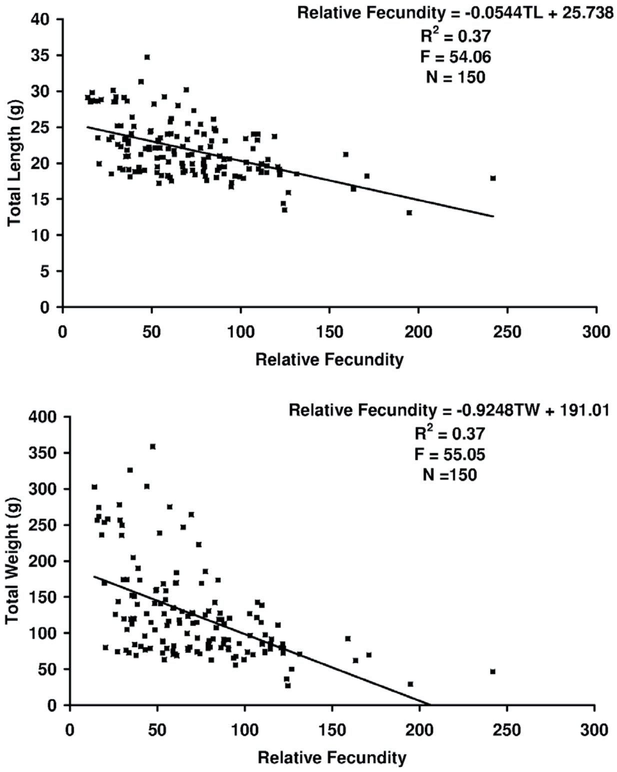

Fig. 6. *Relationship between relative fecundity and fish total weight (mm) and total length (g) of female trout barb* C. trutta *in the River Meymeh (western Iran).*

1627 eggs, which was observed in an age 1+ female of 79.97 g, and maximum *AF* (18329 eggs) was observed in an age 6+ of 264.23 g. Mean *AF* was 7594 (± 283.04 *SE*) eggs per female. *AF* was found to increase significantly with increasing fish size (Fig. 5). Mean *RF* was 70 (± 241.86 *SE*), ranging from 14 to 242 eggs·g^{-1}. *RF* was found to decrease significantly with both fish *TL* and *TW* (Fig. 6).

Discussion

Life-history variables of organisms are often known to vary among habitats and geographical locations, and the trout barb of the Tigris-Euphrates system of western Iran is no exception. Prior to the present study, no published data were available on the life history of this species in Iran, though information is available for some other *Capoeta* species (e.g. *C. capoeta gracilis*, *C. damascina*) in northern and central Iran. Therefore, comparisons are only possible with other *Capoeta* species and with trout barb populations in other countries.

As with other *Capoeta* species, trout barb was found to be reasonably fast growing and short lived (< 7+ years in both sexes), with females exhibiting a much wider range in length and a higher maximum length. Observed maximum age in the River Meymeh is lower than those reported in Turkish waters: 10+ in the River Tigris (Ünlü 1991), the Euphrates drainage (Gül et al. 1996), 7+ in the Karakaya Reservoir of the River Euphrates. Differences in maximum length are also observed between populations, with trout barb of the River Meymeh being smaller that those recorded in Turkey: 34.60 cm *TL* in the Keban Reservoir (Polat 1987), 36.6 cm *TL* in the Turkish Euphrates (Gül et al. 1996) and 37.70 cm *TL* in the Karakaya Reservoir (Kalkan 2008). Variations in maximum age and fish size can usually be explained by differences in food resource availability, individual growth rates, natural selection processes, and/or exploitation patterns. Because trout barb is not subject to commercial exploitation in the Meymeh basin, environmental conditions are the likely sources of the observed variations.

Trout barb growth is negatively allometric in the River Meymeh, with differences between males and females explainable by differences in the size distributions of the two sexes. In the River Meymeh population, the observed slope (*b*) values, which reflect the influence of local environmental factors on growth (Ismen 2005), differ from those found for the species in Karakaya Reservoir (Kalkan 2008), where positive allometric growth was reported for females (b = 3.03) and negative allometric growth for males (b = 2.93).

The estimated maximum length (L_∞) values appear to be reasonable, given that the largest values reported for the species are 52.7 cm and 45.8 cm (www.briancoad.com). A trade-off between growth rate (*k*) and maximum theoretical size (L_∞) is often found, and this is usually explained by local environmental factors. The higher coefficient '*k*' in males suggests that they undergo rapid early growth and approach their asymptotic length (L_∞) earlier in life. This 'front loading' may explain in part the slight dominance of females in the trout barb of the River Meymeh, with higher survival rates amongst older females. In the Karakaya Reservoir (Turkey) the *VBGF* estimated sizes at age (L_t) were 76.40 in males and 89.5 in females (Kalkan 2008). Favourable environments result in reduced mortality and a shift toward larger maximum size (Dulcic et al. 2003), so the Karakaya Reservoir environment would appear to be a more favourable environment for trout barb than the River Meymeh. However, the estimated K and L_∞ values for Karakaya trout barb (Kalkan 2008) suggest similar growth performance to that observed in the River Meymeh.

The *GSI* values for trout barb than the River Meymeh indicate that the relative investment in reproduction by the two sexes is similar to that reported for the Karakaya Reservoir (Turkey), where a maximum GSI in females (7.91) was achieved in May (Kalkan 2008), slightly later than observed of the River Meymeh population. Even though differences in the timing of spawning has been reported for trout barb in Turkey (Polat 1987, Ünlü 1991, Gül et al. 1996, Kalkan 2008) and Iran (present study), it seems that reproductive investment by females (as expressed by *GSI*) is not significantly different among population, an important parameter in the reproductive strategy for this species.

Relative fecundity in the River Meymeh population of trout barb was lower than the mean value (666 eggs·g^{-1}) for the species in Karakaya Reservoir, which reflects the greater maximum egg diameter (1.9 mm) observed in the River Meymeh population than reported for populations in Turkey: 1.03 mm in Keban Reservoir (Polat 1987), 1.38 mm in the River Tigris (Ünlü 1991), 1.20 mm in the River Euphrates (Gül et al. 1996), and 1.04 mm in Karakaya Reservoir (Kalkan 2008). Lower relative fecundity and larger ova suggests a higher energetic investment per egg in the River Meymeh population, and this increase with increasing female size (see Results). This is also evident in the minimum and maximum values for absolute fecundity (*AF*) compared with those reported (www.briancoad.com) for the Turkish Euphrates (4713-18240 eggs), though trout barb in the River Meymeh demonstrated a wider range of *AF* values as well as an *AF* dependency on fish size. This indicates an increasing total energetic investment in reproduction with increasing fish, but the proportional energetic investment (i.e. energy allocation per unit of fish size) tends to be decreased with increasing in fish size.

In conclusion, the trout barb population in the River Meymeh differs in its life history traits relative to other populations, reflecting adaptations to the environmental conditions associated with the climate of western Iran. Future comparative studies are recommended in order to reveal the processes underlying adaptation in different habitats of distribution range.

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