Growth and Reproductive Properties of an Endemic Species, *Gobio hettitorum* Ladiges, 1960, in Yeşildere Stream, Karaman, Turkey

Yeşildere'de (Karaman, Türkiye) Yaşayan Endemik Bir Tür Olan Gobio hettitorum'un Ladiges, 1960, Büyüme ve Üreme Özellikleri

Research Article

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ABSTRACT

The age composition, growth parameters and reproductive properties of *Gobio hettitorum*, Ladiges, 1960 caught in Yeşildere Stream, Karaman (Central Anatolia), were studied by sampling carried out between July 2006 and June 2007. A total of 498 specimens were examined. The age composition of the species ranged from 0 to 5. The specimens of the population were 44.97% (224) male, 47.99% (239) female and 7.03% (35) unidentified. The mean fork length and weight of the samples ranged from 30.0 mm to 161.0 mm and 0.29 g to 40.42 g respectively. The average condition factors varied from 1.03 to 1.38. In females, the average maximum condition factor was 1.59 in June 2007 and in males, it was 1.42 in October 2006. The reproductive period of *G. hettitorum* was recorded from March to July, and average maximum gonadosomatic index values were estimated to be 12.94 for females and 2.33 for males in May 2007. According to the gonadosomatic index values, the maximum egg diameter of females was 0.74 mm in May 2007. Fecundity was calculated as 420 (age class 2) to 4.418 (age class 5) eggs/female.

There are few studies on the growth and reproductive strategy of the genus Gobio in Europe. The current study investigated the growth and reproductive characteristics of G. hettitorum inhabiting Yesildere Stream, providing important information for the conservation of this endemic species.

Keywords
Growth; Reproduction; Endemic species; *Gobio hettitorum*

ÖZET

Karaman-Yeşildere'den yakalanan *Gobio hettitorum*'un yaş kompozisyonu, büyüme parametreleri ve üreme özellikleri Temmuz 2006 ve Haziran 2007 yılları arasında çalışılmıştır. Toplam 498 birey incelenmiştir. Türün yaş kompozisyonu 0-5 aralığındadır. Populasyondaki bireylerin 44.97% (224)'si erkek, 47.99% (239)'u dişi ve 7.03% (35)'ün cinsiyeti ise tanımlanamamıştır. Örneklerin ortalama çatal boy ve ağırlıkları sırasıyla 30.0 mm - 161.0 mm ve 0.29 g - 40.42 g aralığında dağılım göstermektedir. Ortalama kondisyon faktörü 1.03 ile 1.38 arasında değişmektedir. Dişilerde en büyük kondisyon faktörü haziran 2007'de 1.59, erkeklerde ise ekim 2006'da 1.42'dir. *Gobio hettitorum*'un üreme periyodu Mart-Haziran aylarında tespit edilmiştir. Ortalama en büyük GSİ değeri, dişilerde 12.94, erkeklerde 2.33 olarak Mayıs 2007'de saptanmıştır. GSİ değerine göre dişilerde en büyük yumurta çapı 0.74 mm. olarak Mayıs 2007'dedir. Fekondite 420 (iki yaş sınıfı) ile 4418 (5 yaş sınıfı)arasında hesaplanmıştır.

Avrupa'da Gobio cinsinin büyüme ve üreme biyolojisi üzerine az sayıda çalışma vardır. Endemik bir türün korunması için önemli bilgiler sağlayacak olan bu çalışmada Yeşildere'de yaşayan *G. hettitorum*'un büyüme ve üreme özellikleri incelenmiştir.

Anahtar Kelimeler: Büyüme; Üreme; Endemik tür; *Gobio hettitorum*

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INTRODUCTION

Anatolia is one of the most important zoogeographical regions in the world due to its location at the junction of three major biogeographical areas, Holarctic, Sino-indian and African. Owing to its complex geological structure, the number of freshwater fish are abundant and the level of endemism is fairly high. Kosswig [1] investigated a series of subspecies of the Palearctic *Gobio gobio* and the closely related endemic species, *Gobio hettitorum*, in Central Anatolia and maintained that all *Gobio taxa* have inhabited Central Anatolia for a long period of time. In addition, Bănărescu [2] argued that the species and subspecies of the genus *Gobio* found in Turkey were of Palearctic European origin.

Current taxonomic knowledge on the genus *Gobio* indicates that at least 7 endemic species inhabit Turkish waters [3, 4]. Based on the biometric characteristics of 5 *Gobio gobio* subspecies from Turkey, Erk'akan et al. [3], argued that *Gobio gobio insiyanus* could be considered a distinct species as it exhibits 24 diagnostic characteristics different from other Anatolian *G. gobio* subspecies. Furthermore, Naseka et al. [4] indicated that with the fishes previously referred to as subspecies of *Gobio gobio* at least 7 species, *Gobio gymnostethus* Ladiges, 1960, *G. hettitorum* Ladiges, 1960, *G. microlepidotus* Battalgil, 1942, *G. intermedius* Battalgil, 1943, *G. insuyanus* Ladiges, 1960, *G. battalgilae* [4], *G. maeandricus* Naseka, Erk'akan, Küçük, 2006 are living in Turkey.

Yeşildere stream is located 12 km east of the city of Karaman. It is about 80 km long and flows from the Taurus mountains to the plateau of Canhasan. The stream has an important role in Central Anatolia in harboring several endemic fish species such as *Gobio hettitorum* [5], *Oxynoemacheilus eregliensis* [6], and *Capoeta pestai* [7] (Figure 1). According to the IUCN Red List [8] the major threats to endemic freshwater species are water pollution, water extraction, intrinsic factors such as restricted range and limited dispersal, invasive species and the construction of dams. Before national and international conservation laws for endemic species can be specified, biological, ecological and habitat structure for endemic species must first be determined.

There are few studies on the growth and reproductive strategy of the gudgeon *Gobio gobio* in Europe [9, 10]. Sivrikaya [11] investigated the growth and reproductive biology of an endemic species, *Gobio gymnostethus* Ladiges, 1960 in Melendiz stream, which is located in Central Anatolia. However, until now, there has been no research conducted with regards to the growth and reproductive biology of *G. hettitorum,* another species endemic to Turkey. Hence, the aim of the current study was to investigate the growth and reproductive characteristics of *G. hettitorum* inhabiting Yeşildere Stream.

MATERIAL AND METHODS

Specimens were captured monthly by electrofishing between July 2006 and June 2007. All specimens (n=498) were preserved in formaldehyde (4%) and taken to the laboratory where fork length (FL, mm), weight (g) and sex were recorded. The age of the specimens was determined by scales. Growth in length and weight was examined, and relative growth in length (RGL) and weight (RWL) was calculated by the following formulas: RGL = (Lt-Lt-1 / Lt-1) x 100; RWL = (Wt-Wt-1 / Wt-1) x 100 [12,13].

Age-length, age-weight and length-weight relationships were calculated related to the age classes. The condition factors were determined by using the following formula: $K= W/L^n x100$ [14].

In order to determine the age-length relationship within the samples, Von Bertalanffy Equation (1957) was used: $(Lt = L_\infty\{1 - exp[-K^{(t-t_0)}]\})$

The sex of bigger fish was determined through macroscopic examination of the gonads, while the sex of smaller fish was recorded by microscopic examination. The gonads were removed and weighed to the nearest 0.01 g. The reproductive period was examined by means of monthly changes in the gonadosomatic index (GSI) which was calculated by using the formula GSI = (Gonad weight (g) / Total weight) x 100 [13]. The number of eggs was estimated by the gravimetric method using ovaries preserved in formaldehyde (4%). Also, fecundity

Figure 1. Map of Yeşildere Stream, Karaman [16](1)

was calculated by using the gravimetric method [15].

Statistical significance between growth, condition factor and gonadosomatic index (GSI) for the males and females within the same age classes was analysed by ANOVA and t-test.

RESULTS

AGE COMPOSITION

The age composition of the sample ranged from 0 to 5 with most specimens belonging to age class 3 in both sexes, accounting for 54.42%, whereas age class 0 represented 3.01% of the total.

Table 1. Age composition of *G. hettitorum* from Yeşildere Stream.

	Female		Male		Female +Male	
Age Class	N	N%	N	N%	N	N%
0	-	-	-	-	15	03.01
1	-	-	14	02.81	34	06.83
2	67	13.45	42	08.43	109	21.89
3	130	26.10	141	28.31	271	54.42
4	32	06.43	17	03.41	49	09.84
5	10	02.01	10	02.01	20	04.01
Total	239	47.99	224	44.97	498	100

Age composition and sex distribution of all specimens are given in Table 1.

GROWTH

Of the 498 specimens ranging from 30.0 to 161.0 mm fork length, 224 were males (44.97%), 239 were females (47.99%), and 35 unidentified (7.03%). The predominant fork length of males ranged from 38.0 to 150 mm and that of females from 55.0 to 161 mm (Figure 2; Table 2). Weight distribution was found to range from 0.5 to 35.3 g for males and from 1.7 to 64.1 g for females (Figure 3; Table 3).

The average fork lengths (mm) with the minimum, maximum, standard error and relative growth in length (RGL) of males, females and combined sexes are given in Table 2. The maximum relative growth length in the population was calculated as 0.57 in age class 0. As shown in Table 2, maximum annual increase observed was between the year 2 and 3 in both sexes. Length increased with age and average fork length was statistically important in age class 3 between male and female ($P < 0.05$). Age-length relationships in males, females and combined sexes are given in Figure 4.

The average weights (g) with the minimum, maximum, standard error and relative growth in weight (RGW) of males, females and combined sexes are given in Table 3. As demonstrated, the maximum annual increase throughout the population was found in age class 1, whereas it was 7.31 and 2.08 in males and females respectively in age class 2.

Mean weight was significantly different in age

Table 2. Minimum, maximum, average fork length (mm), and relative growth in lenght (RGL) of *G. hettitorum* from Yeşildere Stream 1

		Female W±SD			Male W±SD			Female+Male W±SD	
Age	N	(Min-Max)	RWL	N	(Min-Max)	RWL	t-test	N	(Min-Max)	RWL
0	-	-	-	-	-	-	-	15	0.29±0.03 (0.1-0.5)	0.72
1	-	-	-	14	0.5	-	-	34	0.5	5.04
2	67	3.88±0.17 (1.7-7.6)	2.08	42	1.7	7.31	P<0.05	109	3.02 ± 0.14 (1.7-7.6)	3.33
3	130	11.95 ± 0.40 (5.5-25.0)	1.59	141	14.13 ± 0.47 (5.1-28.3)	0.48	P<0.05	271	13.09 ± 0.32 (5.1-28.3)	1,1
4	32	30.93 ±0.88 (21.9-41.0)	0.47	17	20.9	0.69	P<0.05	49	27.52 ± 0.89 (20.9-41.0)	0.47
5	10	45.54 ± 2.76 (35.9-64.1)	-	10	35.3	-	P<0.05	20	40.42 ± 1.79 (35.3-64.1)	-

Table 3. Minimum, maximum, average weight (g) and relative growth in weight (RGW) of G. hettitorum from Yeşildere Stream

	Female FL±SD			Male FL±SD				Female+Male FL±SD		
Age	N	(min-max)	RWL	N	(min-max)	RWL	t-test	N	(min-max)	RWL
0	-	-	-	-	-	-	-	15	30.00 ± 0.97	0.57
1	-	-	-	14	49.14 ± 1.91 (38.0-54.0)	0.35	-	34	47.18 ± 0.94 (38.0-54.0)	0.42
2	67	67.48 ± 0.82 (55.0-77.0)	0.39	42	66.13 ± 1.10 (54.0-77.0)	0.5	P>0.05	109	66.96 ± 0.66 66.96 ± 0.66	0.44
3	130	93.96 ± 0.96 (75.0-122.0)	0.38	141	98.95 ± 0.99 (75.0-121.0)	0.32	P<0.05	271	96.57 ± 0.71 (75.0-122.0)	0.34
4	32	129.24 ± 0.86 (122.0-139.0)	0.15	17	130.18 ± 1.45 (122.0-141.0)	0.12	P>0.05	49	129.56 ± 0.75 (122.0-141.0)	0.14
5	10	149.00 ± 2.12 (142.0-161.0)	-	10	146.30 ± 0.75 (144.0-150.0)	-	P>0.05	20	147.65 ± 1.14 (142.0-161.0)	-

classes 2, 3, 4 and 5 between sexes of the same age. Age-weight relationship of the species is also shown in Figure 5.

The length-weight relationship within the population is given in Figure 6. As demonstrated, a higher rate of growth in length was associated with young age whilst a higher rate of weight increase was associated with old age.

CONDITION FACTOR

The condition factor is important to show the length-weight relationship and nutrient abundance in the environment. The mean condition factor values of *G. hettitorum* was calculated as a minimum of 0.52 in age class 2 and a maximum of 1.38 in age class 3. The average condition factors with minimum, maximum and standard error of males, females and combined sexes are given in Table 4. As demonstrated, the average condition factor was statistically significant between males and females in age classes 2, 4 and 5, additionally the average condition factor was found to change with time. Monthly variation of the condition factor is plotted in Table 5. The maximum condition factor of the whole population of *G.*

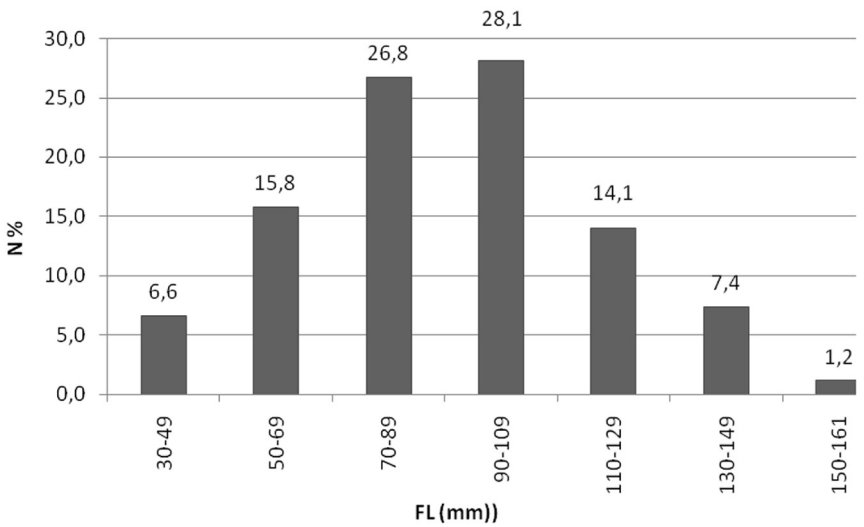

Figure 2. Length distribution of *G. hettitorum* from Yeşildere Stream.

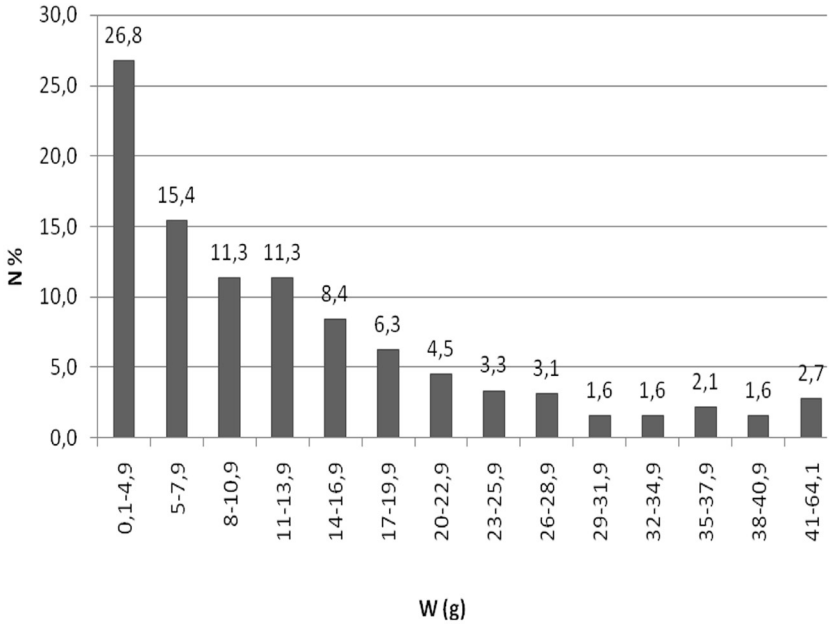

Figure 3. Weight distribution of *G. hettitorum* from Yeşildere Stream.

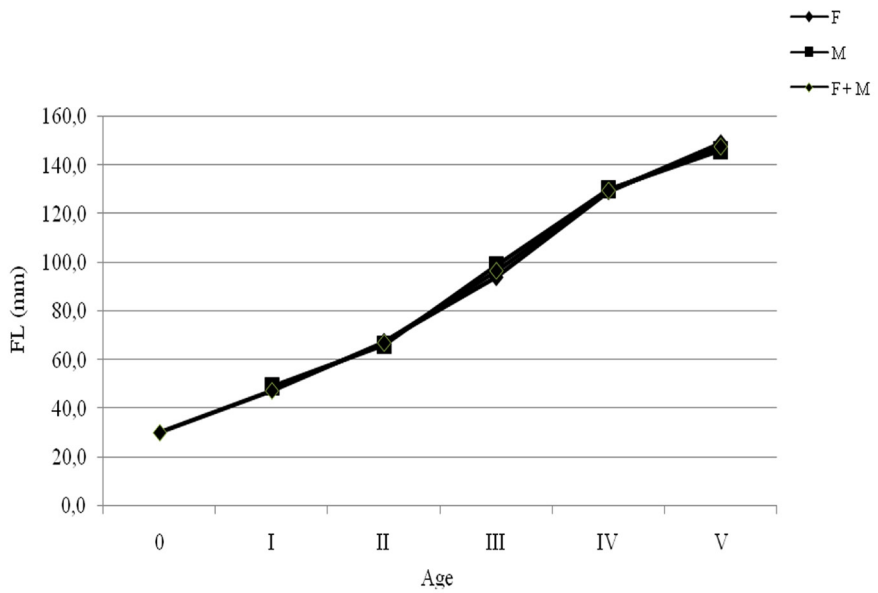

Figure 4. Age-length relationship in *G. hettitorum* from the Yeşildere Stream

hettitorum was calculated as 1.77 in March 2007. The maximum condition factor was 1.77 in March 2007 for males whilst it was 1.79 in June 2007 for females.

REPRODUCTION

A total of 463 fishes were sexed, of which 224 (48.38%) and 239 (51.62%) were females and males respectively. The sex ratio of the population was 1.1:1 (F:M), with the proportion of females being higher than that of males. Gonads were macroscopically visible; > 38 mm FL for males and > 55 mm FL for females. The sexual maturity age of males and females were 1 and 2 respectively.

Table 4. The condition factors in the age classes of *G. hettitorum* from Yeşildere Stream

	Female		Male			Female + Male	
Age Class	N	C.F ± SE (min.-max.)	N	C.F ± SE (min.-max.)	t-test	N	C.F ± SE (min.-max.)
0	-	-	-	-	-	15	1.03 ± 0.05 (0.72-1.37)
1			14	0.45 ± 0.07 (0.32-0.91)		34	0.52 ± 0.03 (0.32-0.91)
2	67	1.21 ± 0.02 (0.83-1.66)	42	0.63 ± 0.32 (0.37-1.08)	P< 0.05	109	0.98 ± 0.03 (0.37-1.66)
3	130	1.37 ± 0.13 (1.07-1.79)	141	1.37 ± 0.14 (0.96-1.82)	P> 0.05	271	1.38 ± 0.01 (0.96-1.82)
4	32	1.42 ± 0.02 (1.12-1.74)	17	0.96 ± 0.32 (0.75-1.15)	P< 0.05	49	1.27 ± 0.04 (0.75-1.74)
5	10	1.36 ± 0.03 (1.25-1.54)	10	1.13 ± 0.02 (1.05-1.18)	P< 0.05	20	1.25 ± 0.03 (1.05-1.54)

Table 5. Monthly variation of the condition factors of *G. hettitorum* from Yeşildere Stream.

	Female		Male		Female + Male	
Months	N	C.F ± SE (Min.-Max.)	N	C.F ± SE (Min.-Max.)	N	C.F ± SE (Min.-Max.)
July 2006	24	1.41 ± 0.03 (1.13-1.69)	26	1.12 ± 0.08 (0.32-1.67)	50	1.26 ± 0.05 (0.32-1.69)
August 2006	9	1.29 ± 0.03 (1.13-1.43)	15	1.14 ± 0.10 (0.38-1.59)	25	1.19 ± 0.07 (0.38-1.59)
Sep. 2006	28	1.26 ± 0.02 (1.03-1.49)	16	1.27 ± 0.05 (0.68-1.58)	51	1.24 ± 0.02 (0.68-1.58)
October 2006	12	1.37 ± 0.02 (1.27-1.46)	17	1.42 ± 0.04 (0.87-1.57)	29	1.40 ± 0.03 (0.87-1.57)
Novem. 2006	61	1.35 ± 0.01 (1.13-1.70)	47	1.11 ± 0.05 (0.34-1.53)	115	1.21 ± 0.03 (0.34-1.70)
Jan. 2007	21	1.37 ± 0.03 (1.17-1.59)	13	1.29 ± 0.12 (0.37-1.57)	36	1.31 ± 0.05 (0.37-1.59)
March 2007	27	1.23 ± 0.02 (1.02-1.50)	31	1.04 ± 0.07 (0.40-1.77)	63	1.10 ± 0.04 (0.40-1.77)
April 2007	38	1.23 ± 0.03 (0.83-1.62)	33	0.94 ± 0.05 (0.36-1.29)	83	1.03 ± 0.04 (0.34-1.62)
May 2007	9	1.56 ± 0.04 (1.40-1.74)	11	1.12 ± 0.11 (0.45-1.67)	20	1.31 ± 0.08 (0.45-1.74)
June 2007	7	1.59 ± 0.07 (1.33-1.79)	18	1.21 ± 0.10 (0.37-1.82)	26	1.28 ± 0.09 (0.36-1.82)

In addition, males matured at an average FL of 49.14 mm and females matured at an average FL of 67.48 mm.

The gonadosomatic index (GSI), which is used to determine the reproductive period, was calculated from a sample of 224 males and 239 females. The average GSI values for the whole study period were 2.43 for males in age class 1 and 10.48 for females in age class 4. GSI values were significantly higher for females than males. Monthly variations of GSI values are given in Figure 7. The maximum GSI values for males were 11.76 in June 2007 and the maximum GSI values for females were 21.88 in April 2007.

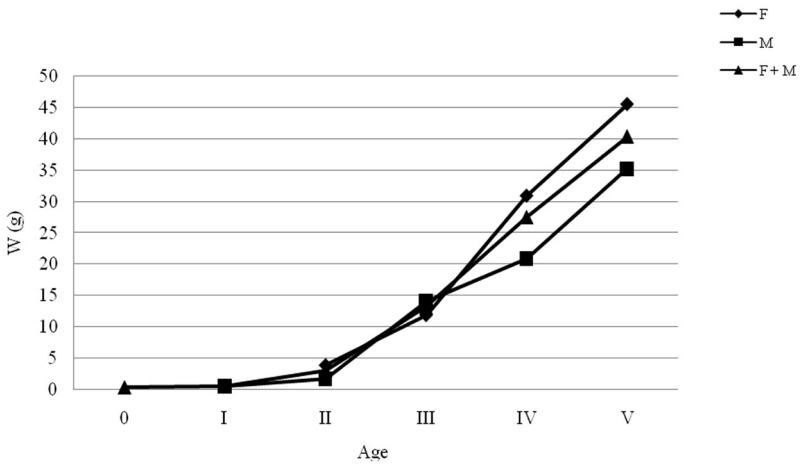

Figure 5. Age-weight relationship in *G. hettitorum* from Yeşildere Stream

In addition, the maximum mean value of GSI was 2.33 and 12.94 in May 2007 for males and females respectively. It follows that the reproductive period of *G. hettitorum* occurs between March and June. Egg diameter was correlated with the GSI value and the maximum egg diameter was 0.74 mm in May (Table 6).

Fecundity was estimated from 110 ripe females, ranging from 72.80 to 149.00 mm FL and 5.14 to 45.54 g. (Table 7). As the fish length, weight, gonad weight and age increased, so did fecundity. In line with this, fecundity varied from a mean of 420 eggs per female (age class 2) to a mean of 4.489 eggs per female (age class 5).

DISCUSSION

Gobio hettitorum is an endemic species only inhabiting Yeşildere Stream in Central Anatolia. Determination of growth and reproductive properties of this species is of great importance for the conservation of its natural habitat. The age composition provides important information about the life requirement, the age and size distribution of fishes in the populations, the

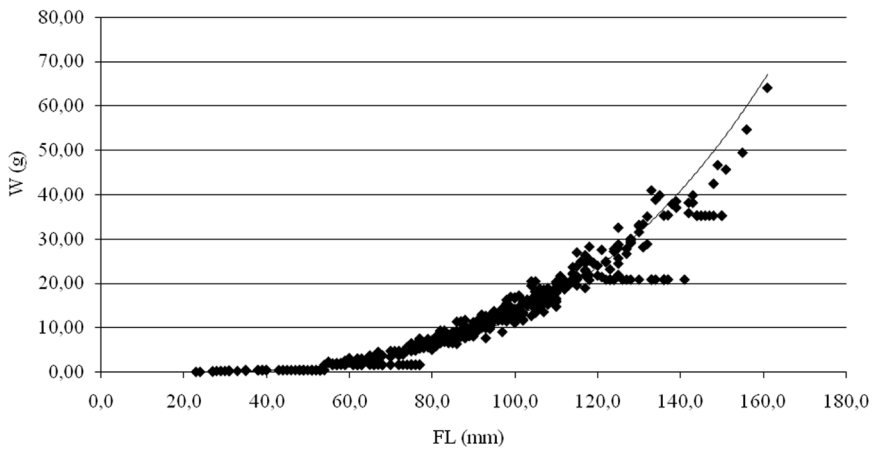

Figure 6. Length-weight relationship in *G. hettitorum* from Yeşildere Stream

maximum and minimum growth rate period, and the conservation of fish stocks, all of which are necessary for the establishment of fishery activity [17]. It was determined that the age distribution of *G. hettitorum* ranged between 0 and 5, from 1 to 5 for males and from 2 to 5 for females (Table 1). Age class 3 was predominant in both sexes. Age ratios of the specimens were 3.01%, 6.83%, 21.89%, 54.42%, 9.84% and 4.01%, for age classes 0 to 5 respectively. Sivrikaya [11] reported that the age composition of *Gobio gymnostethus* was from 0 to 7, out of which age class 5 was predominant. Age distribution of *Gobio gobio* caught in Segure River (Spain) ranged between

The maximum relative growth length was recorded as 0.57 for age class 0 in *G. hettitorum*, whilst it was 0.40 for age class 4 in *G. gymnostethus* [11]. Annual length rate decreased with age in *G. hettitorum* (Table 2; Figure 4). The decrease in relative growth length with age can be explained by the changes in activity as a result of sexual maturity [20].

As shown in Table 3, the mean weight of *G. hettitorum* in Yeşildere Stream was 0.29 g (for age class 0) and 40.42 g (for age class 5). In comparison, the weight distribution of the *G. gymnostethus* population caught in Melendiz Stream ranged

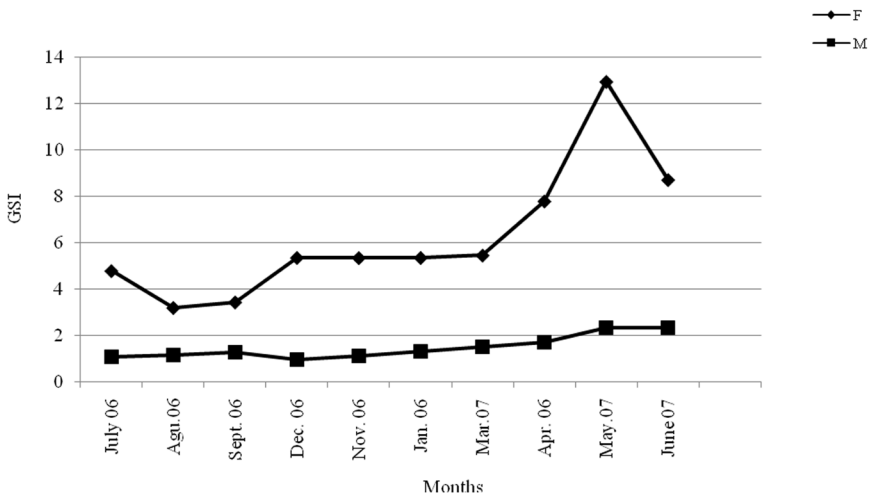

Figure 7. Monthly gonadosomatic index value of *G. hettitorum* from Yeşildere Stream

0 and 5 [10]. According to Bennett [18], younger fish should naturally be more abundant in the population, if this is not the case, this could be an indication of excessive hunting.

The size range of the *G. hettitorum* population was between 23.0 and 161.0 mm, with a main distribution between 70.0 and 110.0 mm (54.9%) (Figure 2). The fork length distribution was 38.0-150.0 mm and 55.0-161.0 mm for males and females respectively (Table 2). The fork length distribution of *G. gymnostethus* caught in Melendiz Stream was reported as 30.0-151.0 mm [19] whereas the maximum length of *G. gobio*, caught in Segure River (Spain) was recorded as 98 mm and 101 mm for males and females respectively [10].

between 0.4 g and 40.9 g [11]. The dominant weight distribution of *G. hettitorum* ranged between 0.4 and 7.9 g with the ratio of 47.5% (Figure 3).

As can be seen, the weight distribution of the two species displays a high degree of similarity. The annual rate of weight increase of *G. hettitorum* was statistically significant for corresponding age classes in both sexes. The maximum relative growth weight was calculated as 0.54 in age class 1. This suggests that relative growth weight decreases with age, whereas weight increases with age (Figure 5).

The length-weight relationship of *G. hettitorum* was shown to be isometric; growth rate in length was the highest in younger age, whilst growth rate

Table 6. Monthly variation in mean egg diameters of G. hettitorum from Yeşildere Stream

Months	N	Egg daimeter(mm)	SE
July 2006	7	0.69	0.07
August 2006	5	0.28	0.01
Sep. 2006	10	0.31	0.02
October 2006	12	0.30	0.01
Novem. 2006	7	0.38	0.03
Jan. 2007	18	0.39	0.01
March 2007	11	0.36	0.02
April 2007	8	0.54	0.02
May 2007	7	0.74	0.03
June 2007	5	0.66	0.04

Table 7. Fecundity of *G. hettitorum* from Yeşildere Stream

Age class	N	FL. (mm)	W (g)	Fecundity
2	11	72.80	05.14	420
3	59	98.22	13.77	808
4	30	129.27	31.30	02.228
5	10	149.00	45.54	04.489

in weight was the highest in older age (Figure 6). Physico-chemical and biological factors may have an effect on the growth rate in length and weight of fish, both directly and indirectly. The average condition factor values of *G. hettitorum* ranged from 1.21 to 1.42 in females and from 0.45 to 1.37 in males, between age classes 1 and 5 (Table 4). The mean minimum and maximum condition factors calculated for the whole population were 1.03 in April 2007 and 1.40 in October 2006 respectively (Table 5) whereas the minimum and maximum condition factor values of *G. gymnostethus* were calculated as 1.07 in July 2005 and 1.54 in June 2006 respectively [11]. Gomiero and Braga [21] demonstrated that the decrease in the condition factor was related to the reproductive period and feeding habits. In addition, Cetinkaya et al. [22] reported that the condition factor showed great variety before and after spawning. In line with this, the condition factor of *G. hettitorum* significantly decreased relative to reproductive period (Table5). According to Lizama and Ambrósia [23], due to maximum metabolic ratio, the condition factor values decreased when the specimens began to spawn. This explains the minimum condition factor value, which was recorded as 0.83 in April 2007 (Table 5). As a result, variation in condition factor may be explained by differences in environmental conditions such as seasonality, quality of food and of water in which the fish inhabit [24].

Growth in fish depends on the species, age, amount of food available – or food intake, food competition between species, prey-predator relationships, sexual maturity age, size, water temperature and amount of dissolved oxygen [25].

Von Bertalanffy Growth Equation was applied to analyze the growth rates within the age classes: $Lt = L_{\infty}\{1 - exp[-K^{(t-t_0)}]\}$. According to this equation, $L\infty = 1064$ mm, $K = 0.1$ and $t_0 = 106$. The value of the parameter $L\infty$ (1064 mm) appears to be quite high. No matter how suitable the natural conditions are, it is not possible for the theoretical growth to reach 1064mm in such a small-sized fish. In the same way, t_0 is generally expected to have a negative value. However, in our study, not only does it have a positive value but also it is very high. As can be seen in the equation, our study did not conform to the model of Von Bertalanffy. Growth in length of fish is not as regular as is shown in the ideal curve. Food abundance, biotic, abiotic factors such as light and temperature as well as the dynamic and chaotic environments such as rivers may be the cause of

this difference. Consequently, some species of fish living in different ecological conditions may deviate from this modeling [26].

Mann [9] reported that females reached sexual maturity earlier than males in *G. gobio*, whilst Sivrikaya [11] reported that both sexes in *G. gymnostethus* reached sexual maturity in age class 1. However, the sex ratio of *G. hettitorum* specimens, caught between July 2006 and June 2007, was 1.1:1 (F:M). Age at first spawning was 1 in males and 2 in females. The first spawning age and the first spawning period of fish have been shown to have great variation depending on species, size of fishes, environmental factors such as temperature, quality of food, and feeding habits [22,27].

The maximum GSI was calculated as 10.48 for females in age class 4 and 2.43 for males in age class. Moreover, the mean GSI of *G. hettitorum* reached the highest value of 2.33 and 12.94 for males and females respectively in May 2007. The reproductive period of this species occurred from March to June, and the peak spawning period was recorded in April and May (Figure 7). On the other hand, Sivrikaya [11] reported that the reproductive period of *G. gymnostethus* occurred between April and July. The spawning periods of fish vary with respect to their species and the ecological properties of the water in which they live [27]. Egg diameter is related to GSI and the maximum egg diameter was 0.74 mm in May (Table 6).

Fecundity of *G. hettitorum* was 420 (age class 2), 808 (age class 3), 2.228 (age class 4) and 4.489 (age class 5) eggs per female whereas it was 952 (age class 4), 2.604 (age class 5), and 5.310 (age class 6) in *G. gymnostethus* [11]. It is known that fecundity is affected by age, size, species, feeding, season and environmental conditions [27]. As shown in Table 7, fecundity increased with length, weight and age of fish.

The conservation of endemic species is important for biodiversity. In the IUCN Red List [8], it was reported that invasive fish species are a significant threat to freshwater endemic fishes.

The ichthyofauna of Yeşildere stream is composed of the endemic species *Oxynemacheilus eregliensis, Capoeta pestai, G. hettitorum* and an exotic species *Oncorhynchus mykiss* (Walbaum, 1792). According to the IUCN Red List [22], exotic species are one of the major threatening factors to freshwater endemic species.

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