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RESEARCH ARTICLE ARAŞTIRMA MAKALESİ

AGE AND REPRODUCTION FEATURES OF TENCH (*Tinca tinca* (L., 1758)) FROM HIRFANLI DAM LAKE, KIRŞEHIR, TURKEY

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Abstract: Tench (*Tinca tinca*) is an abundant and commercially important cyprinid in shallow vegetated lakes throughout much of Europe and Asia. The current study provides biological baseline data for the population of tench in Hirfanlı Dam Lake, and determines if reproduction characteristics of the Hirfanlı population differs from those in surrounding regions. The overall ratio of males to females was 0.92:1.00, with an age distribution of I-VI age groups, and sexual maturity attained at age III (for males) and IV (for females). Spawning occurred from the end of May to the mid of July, with mean absolute fecundity of 113305 ± 97826 eggs (±S.D) and relative fecundity of 347 ± 228 eggs mm^{-1} of fork length and 184 ± 52 eggs g^{-1} of total body weight. These fecundity values for tench in Hirfanlı Dam Lake differ markedly from those in other regions of Turkey, and must be taken into account when considering lake's future as a resource for fishing and irrigation.

Keywords: Cyprinids, Fecundity, Spawning time

Özet:

Hirfanlı Baraj Gölü (Kırşehir, Türkiye)'ndeki Kadife Balığı (*Tinca tinca* (L., 1758))'nın Yaş ve Üreme Özellikleri

Kadife Balığı (*Tinca tinca*) Asya ve Avrupa'nın birçok sığ göllerinde bol olarak bulunan ve ekonomik önemi olan bir Cyprinid'tir. Bu araştırma Hirfanlı Baraj Gölü'ndeki kadife populasyonu için biyolojik bir veri tabanı oluşturacak ve üreme özelliklerinin civar bölgelerde yaşayan kadife balıklarından farklı olup olmadığını ortaya koyacaktır. Populasyon genelinde erkek dişi oranı 0.92: 1.00, yaş dağılımı I-VI olup eşeysel olgunluğa ulaşma yaşı erkeklerde III, dişilerde IV yaş olarak tespit edilmiştir. Toplam yumurta verimi 113305 ±97826 (± S.Sapma) ve nispi yumurta verimi 347 ±228 yumurta/ mm çatal boy ve 184 ±52 yumurta/ g toplam vücut ağırlığı olarak tespit edilmiştir. Yumurta bırakma Mayıs sonundan Temmuz ortasına kadar devam etmiştir. Hirfanlı Baraj Gölü'ndeki kadifenin fekondite değerleri Türkiye'nin diğer bölgelerinde saptanan değerlerden oldukça farklı olup, balıkçılık ve sulama kaynağı olarak gölün geleceği düşünüldüğünde bu sonuçlar dikkate alınmalıdır.

Anahtar Kelimeler: Cyprinidler, Fekondite, Yumurtlama zamanı

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Introduction

Tench, *Tinca tinca* (L., 1758), is one of the most abundant freshwater cyprinids in Europe and Asia, and is found in a variety of inland waters throughout Turkey (Balık and Çubuk, 2000; Balık et al., 2004; Ergönül and Altındağ, 2005). Despite the country's dependence on large lakes as an important economic resource, and the continued construction of dams for increased hydroelectric power and irrigation potential, very little is known about the fish populations in most lakes, or how these populations might respond to this ever increasing pressure of development.

From an economic perspective, tench is farmed throughout much of Europe (Wedekind et al., 2003), but until recently, was not a significant part of the aquaculture industry in Turkey (Balık et al., 2004). Tench aquaculture is mostly negligible in Turkey despite its popularity in sport fishing (Altındağ et al., 2002) and its low susceptibility to disease compared to other fish species (Svobodova and Kolarova, 2004). From an ecological perspective, tench have been introduced into many Turkish lakes in recent years, and catches have gradually increased (Balık and Çubuk, 2000). Tench are nocturnal, benthic predators of various invertebrate grazers such as gastropod, molluscs, and are known to positively affect periphyton biomass in eutrophic lakes (Herrero et al., 2005; Beklioğlu and Moss, 1998; Adámek et al., 2003).

A few studies have characterized tench reproduction in various inland water bodies throughout Turkey (Yılmaz, 2002; Alaş and Solak, 2004; Benzer et al., 2007). The present study is important in terms of comparison of the results of Benzer et al. (2007) in Hirfanlı Dam Lake during 1996 - 1997. The primary aim of this study is to describe the tench population from Hirfanlı Dam Lake and correlate populations characteristics such as spawning period and fecundity.

Materials and Methods

Hirfanlı Dam Lake is located on the Kızılırmak River, 70 km south of Kırıkkale province in the Central Anatolia region of Turkey (Figure 1). The altitude, mean depth and reservoir area of the lake are 856 m, 83 m and 320 km^2, respectively (DSI, 1973).

Specimens were captured monthly by gill nets of various mesh sizes (18x18 mm, 40x40 mm, 55x55 mm) between June 2001 and May 2002. The fork length (FL) and weight (W) were measured to the nearest 1.0 mm and 0.1 g, respectively. Ten to fifteen scales above the lateral line, below the anterior part of the dorsal fin were removed for age determination. Scales were waited in 4% potassium hydroxide solution for 24 hours and then washed and cleaned with a thin brush. Clean scales were left in 70% alcohol for 5-10 minutes and then mounted dry and bounded tightly between two slides with sellotape (Lagler, 1956). Sex and stage of maturity were ascertained by examination of the gonad tissue either by eye for bigger fish or with the aid of a microscope for smaller ones. The sexual maturity of the gonads was classified as: Stage 1, young individuals which have never spawned yet; stage 2, gonads are of very small size and eggs not visible to the naked eye; stage 3, ripening; eggs visible to the naked eye; stage 4, ripeness; gonads have reached their maximum weight; stage 5, reproduction; gametes run out on the application of the lightest pressure to the thorax and the weight of the gonad rapidly decreases from start to finish of the spawning process; stage 6, spent; gonad has the appearance of an empty sac, usually with a few eggs remaining in females or sperms in males (Nikolsky, 1963). Gonads were removed and weighed to the nearest 0.01 g and preserved in 4% formaldehyde. Sexual maturity and spawning period were determined from monthly variations of the gonadosomatic index (GSI) and egg diameters of samples (Nikolsky, 1963). GSI was calculated monthly from the equation GSI= $(W_g/(W_t–W_g)x100$ where W_g and W_t are gonad weight and total body weight in grams of fish, respectively. To estimate the mean lengths at 50% maturity, a logistic function was fitted to the proportion of the mature individuals by size class using a non-linear regression. The function used was $P= 1/ [1+\exp(-r(L-L_m))]$, where P 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 intercept (Saila et al., 1988).

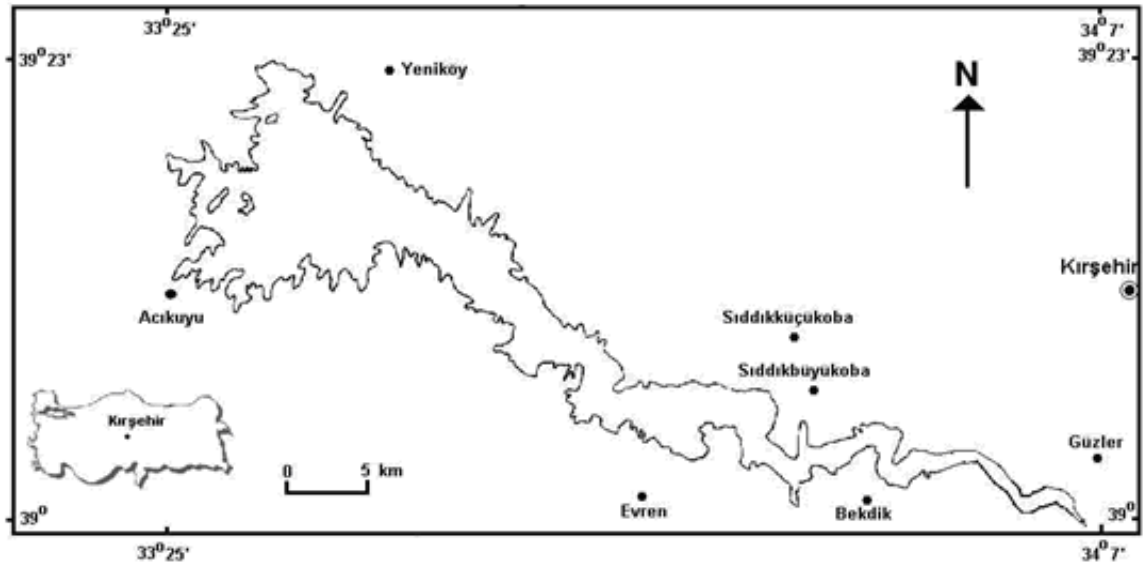

Figure 1. Map of Hirfanlı Dam Lake

Fecundity (F) was estimated by the gravimetric method (Bagenal and Braum, 1978): ovaries were washed for two hours, and three subsamples weighing 1 g each were taken from the front, middle and back parts of each ovary. The eggs in the subsamples were counted. The total number of eggs in each ovary was proportional to the total ovary weight. Relative fecundity was calculated as F_r= F/W (g) and F_r = F/FL (mm). Fecundity (F) – fork length (FL), fecundity – weight (W), fecundity – gonad weight (GW) and fecundity – age (t) relationships were determined from the equation $F= a*x^b$ where F= fecundity, x= length, weight, gonad weight or age, a= a constant and b= an exponent. All data was transformed to a logarithmic form as log$F$= log$a$ + b log$x$ (Bagenal and Braum, 1978). The diameters of 30 eggs taken from the front, middle and back parts of the mature ovaries were measured using a micrometer. The overall ratio of males to females was tested with X^2-test (Sümbüloğlu and Sümbüloğlu, 1994).

Results and Discussion

Sex ratio, age distribution and length frequency

Of the total fish examined, 116 were males (47.93%) and 126 were females (52.07%). The sex ratio of males to females was 0.92:1.00 and was not significantly different from 1.00:1.00 (X^2= 0.41< $X^2_{1,\ 0.05}$= 3.84). The differences between the sexes according to age were significant in age groups III and V ($p<0.05$) (Table 1).

Females in all age groups were dominant in the population except in the third age. The ages of fish ranged from I to VI years and the third age group was dominant in the population (33.1%). The sampled fish ranged from 7.9 cm to 40.2 cm FL. The majority group (63.6%) belonged to 20-26 cm FL (Table 1).

Age and length at first maturity

The smallest mature female captured was 22 cm FL (250 g total weight) and the smallest mature male was 19.6 cm FL (119 g total weight). First spawning age was IV for females and III for males. The maturity ogives for tench showed that 50% of females $P= 1/ [1+ \exp^{(-0.995(L-24))}]$ and males $P= 1/ [1+ \exp^{(-0.972(L-22))}]$ were sexually mature at fork lengths of 24 and 22 cm, respectively (Figure 2).

Gonad development and spawning period

Spawning occurred from the end of May (19ºC, GSI= 9.56) to the mid of July (25.8ºC, GSI= 4.35). After spawning, GSI values were almost steady until February. GSI increased drastically from February (2.16) to May (9.56) (Figure 3). Similarly, egg diameters of mature females increased rapidly from February to May. The mean egg diameter was the smallest in July (0.22 mm) and the highest in May (1.08 mm) (Figure 4). Six different gonad maturity stages were determined for females. The monthly distribution of the maturity stages in the period from June 2001 to May 2002 is shown in Figure 5.

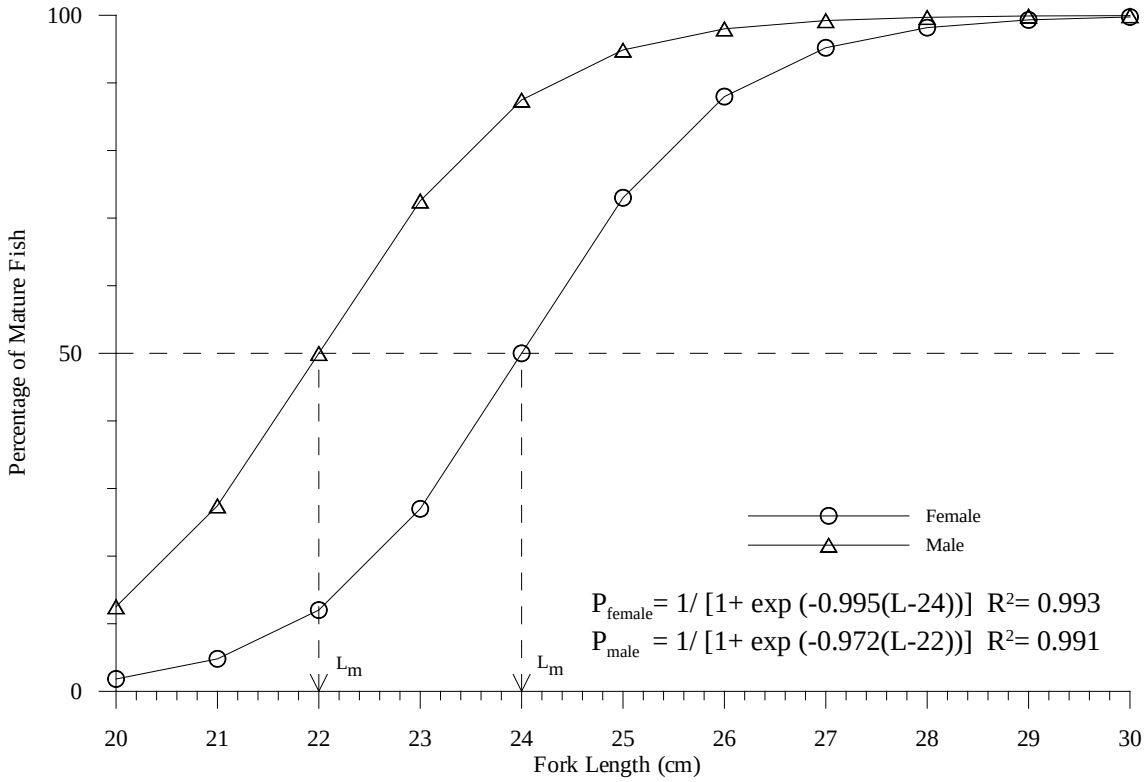

Figure 2. Ogive of first maturity for females and males of *T. tinca* from Hirfanlı Dam Lake

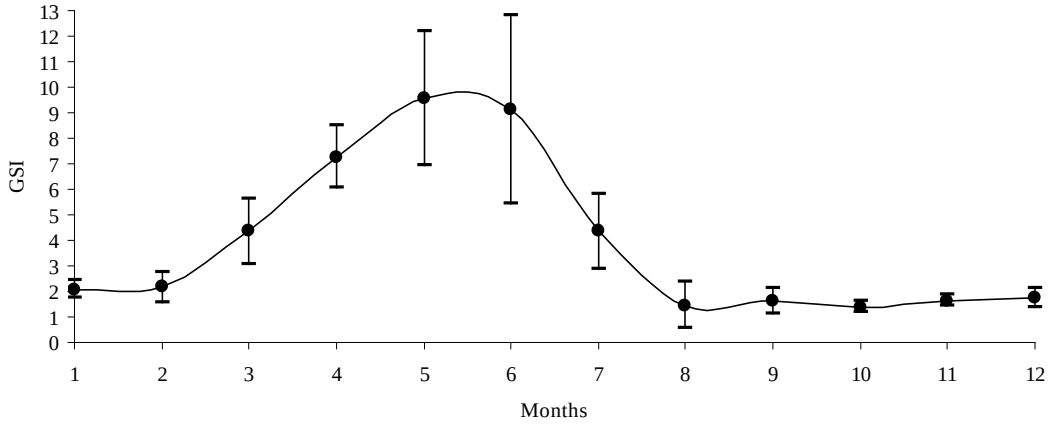

Figure 3. Monthly variations in Gonadosomatic Index (GSI) values with Standard Deviation (SD) of *T. tinca*

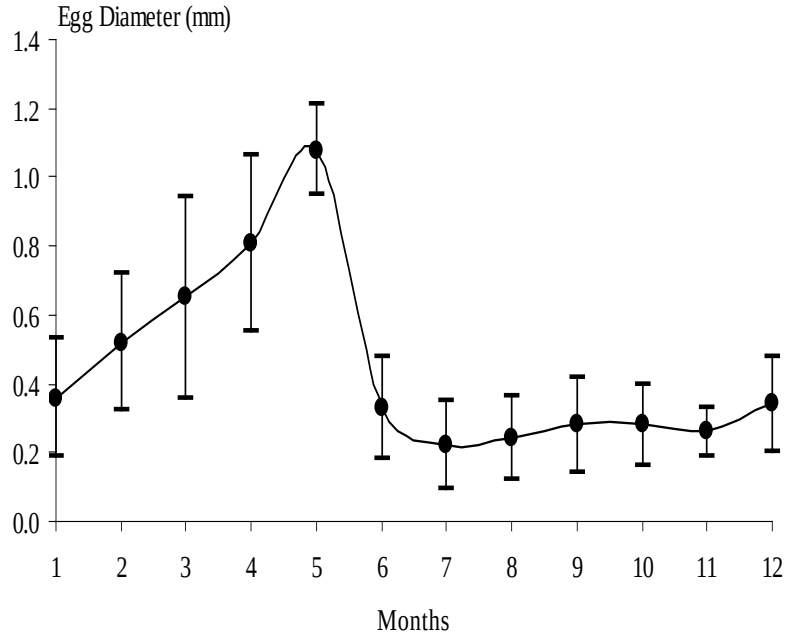

Figure 4. Monthly variations in egg diameter (mm) with Standard Deviation (SD) of *T. tinca*

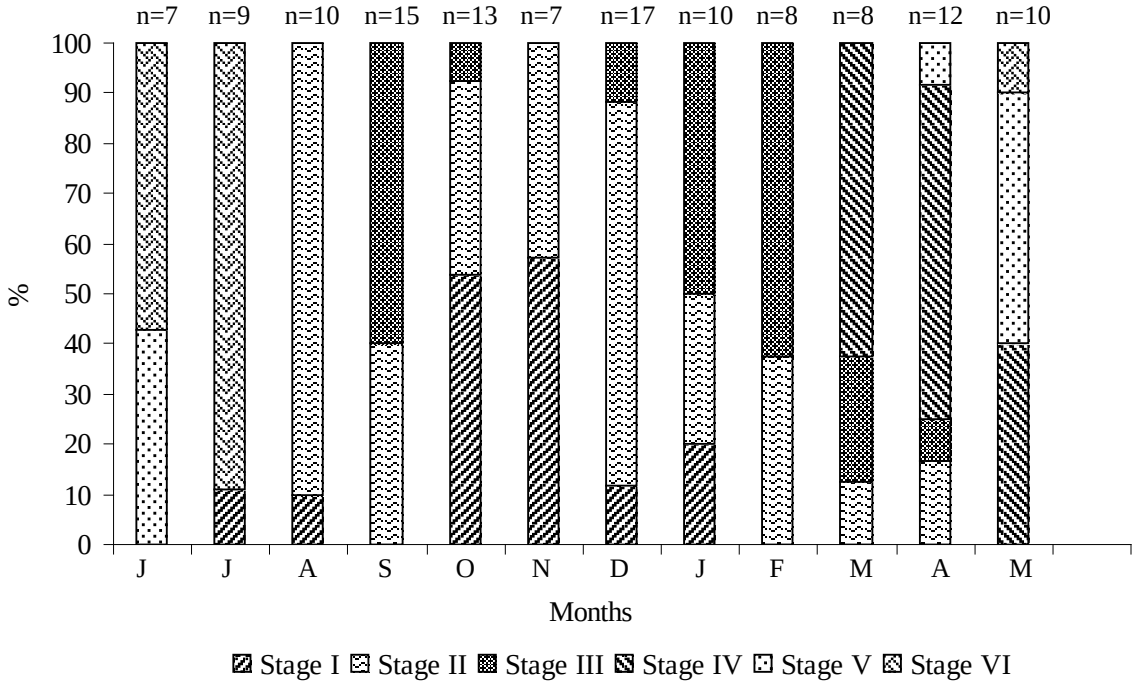

Figure 5. Monthly changes in the maturity stages of *T. tinca* in Hirfanlı Dam Lake

Fecundity

The number of oocytes of 24 females at maturity stages IV-V ranged from 27,010 (25.1 cm FL and 282 g body weight) to 380,639 (40.2 cm FL and 1230 g body weight), while mean absolute fecundity was 113,305 ± 97,826 (S.D). The value of relative fecundity was 347 ± 228 eggs mm^{-1} of fork length (minimum value was 108 and maximum 947 eggs mm^{-1}) and 184 ± 52 eggs g^{-1} of total body weight (minimum value was 96 and maximum 309 eggs g^{-1}) (Table 2). Fecundity was positively correlated with length, weight, gonad weight and age of fish. Older and larger fish showed a higher fecundity. The relationships between fecundity (F) – fork length (L), fecundity – weight (W), fecundity – gonad weight (GW) and fecundity – age (t) were described as follows:

$\log F = -1.7423 + 4.5465 \log L$ (r= 0.916),

$\log F = 1.1444 + 1.4105 \log W$ (r= 0.920),

$\log F = 3.3321 + 1.0467 \log GW$ (r= 0.913),

$\log F = 3.2420 + 2.6865 \log t$ (r= 0.691) (Figure 6).

Mean egg diameter was 0.98 ±0.14 (SD) mm in the spawning season (Table 2). Oocytes were also observed in all seasons. The highest mean egg diameter was measured in May (1.08 mm) while the smallest diameter was measured in July (0.22 mm) during the study period (Figure 4).

The tench population of Hirfanlı Dam Lake shows a sex ratio of 0.92 males: 1.00 females, which is not significantly different from 1:1, nor much different from sex ratios reported in other studies (Yılmaz, 2002; Alaş and Solak, 2004). In the present study, the ages of fish ranged from I to VI years and the dominant age group in the population was age III (33.1%). The abundance of age groups older than IV decreased dramatically and no fish were caught older than VI. This age bias may reflect the fishing customs practiced in and around the Hirfanlı Dam.

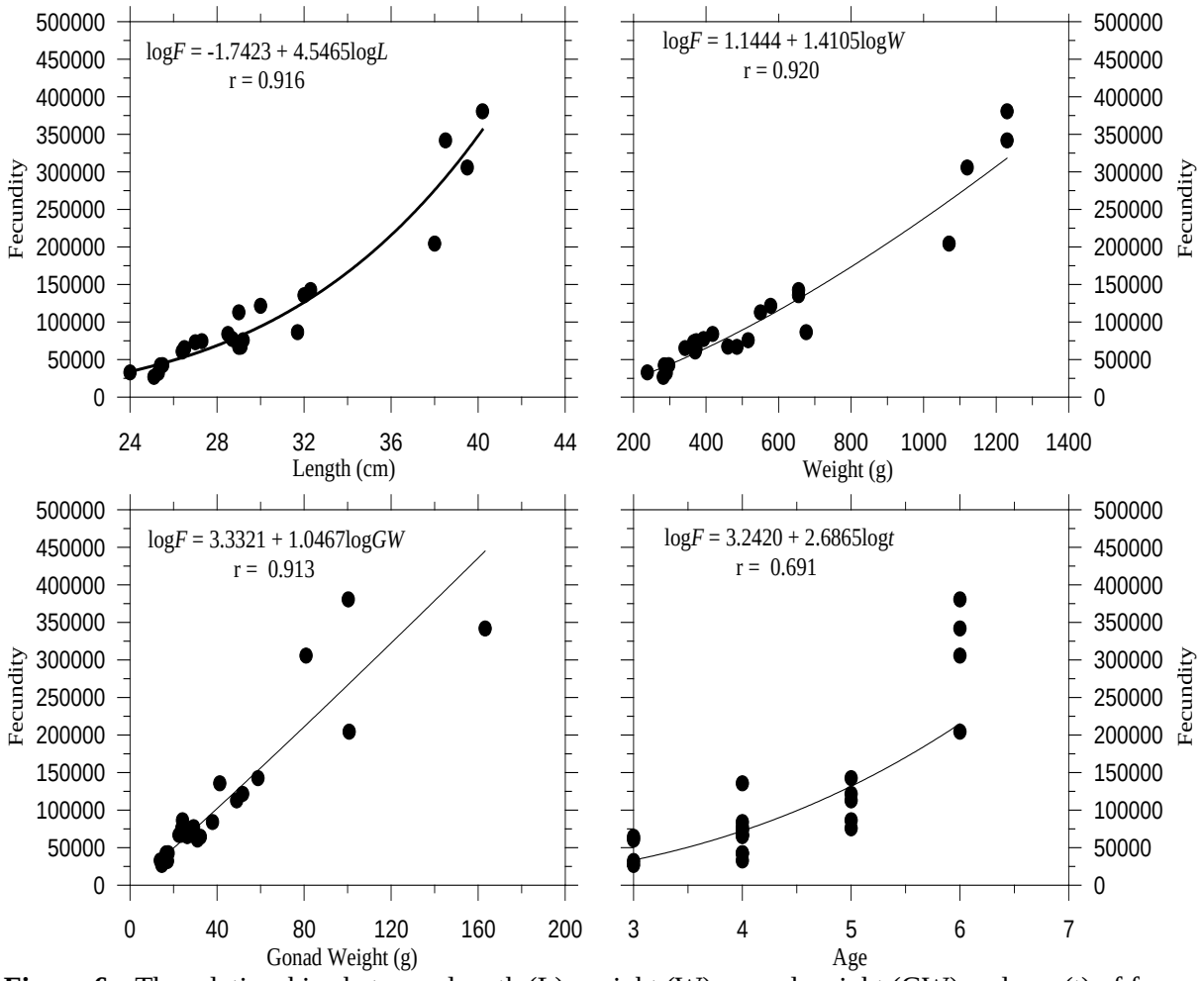

Figure 6. The relationships between length (L), weight (W), gonad weight (GW) and age (t) of female *T. tinca* versus fecundity (F) in Hirfanlı Dam Lake

Table 1. Age-length data for females, males and all individuals of *T. tinca* from Hirfanlı Dam Lake

Size(cm)	Age group (year)						
	I	II	III	IV	V	VI	Total
Females							
10	6						6
12	5						5
14							
16							
18	3						3
20		9	5				14
22	3	14	8	1			26
24	2	10	7	5			24
26		3	7	4			14
28			3	7	3		13
30			1	5	4		10
32				2	4		6
34					1		1
36							
38						1	1
40						2	2
42						1	1
N	19	36	31	24	12	4	126
Percentage	15.1	28.6	24.6	19.0	9.5	3.2	100
Mean L_t (cm)	14.00	21.47	22.95	26.72	29.53	39.05	23.03
±SE	1.24	0.30	0.44	0.52	0.46	0.49	
Mean W_t (g)	61.26	148.53	208.26	339.08	472.08	1162.5	249.36
±SE	14.25	4.53	12.55	22.84	35.43	40.28	
Males							
10	11						11
12	1						1
14							
16	2						2
18	3	2					5
20	1	7	4				12
22		8	17				25
24		7	16	3			26
26			5	8			13
28			4	7			11
30			3	1			4
32				1	2		3
34				1	1		2
36							
38							
40							
42						1	1
N	18	24	49	21	3	1	116
Percentage	15.5	20.7	42.2	18.1	2.6	0.9	100
Mean L_t (cm)	11.41	20.76	22.92	26.31	32.40	40.20	21.69
±SE	0.94	0.35	0.35	0.51	0.40		
Mean W_t (g)	34.03	140.40	192.03	311.24	615.67	1185	197.93
±SE	8.80	5.66	9.49	19.23	64.40		
Combined sexes							
10	17						17
12	6						6
14							
16	2						2
18	6	2					8
20	1	16	9				26
22	3	22	25	1			51
24	2	17	23	8			50
26		3	12	12			27
28			7	14	3		24
30			4	6	4		14

Table 1. Continued

Size(cm)	Age group (year)						
	I	II	III	IV	V	VI	Total
32				3	6		9
34				1	2		3
36							
38						1	1
40						2	2
42						2	2
N	37	60	80	45	15	5	242
Percentage	15.3	24.7	33.1	18.6	6.2	2.1	100
Mean L_t (cm)	12.74	21.18	22.93	26.53	30.11	39.28	22.39
±SE	0.80	0.23	0.27	0.36	0.48	0.44	
Mean W_t (g)	48.01	145.28	198.32	326.09	500.8	1167.0	224.71
±SE	8.66	3.55	7.58	15.11	33.81	31.52	

Table 2. Mean length (cm), weight (g) and fecundity (F) values of *T. tinca* in spawning season

Age	*n*	*L* (cm) ± S.D	*W* (g) ± S.D	*GW*(g) ± S.D	*F* ± S.D	*F/L* ± S.D	*F/W* ± S.D	Egg diam.(mm) ± S.D
III	4	25.82±0.72	328.5±49	23.77±9	46115±19213	177±69	136±38	0.95±0.01
IV	11	27.54±2.22	392.0±114	26.04±8	69323±27416	247±78	174±30	0.89±0.12
V	5	30.44±1.49	595.0±68	41.49±16	107899±26946	354±82	182±41	1.06±1.12
VI	4	39.05±0.99	1162.5±81	111.28±36	308207±75613	787±181	263±50	1.16±0.11
Mean		29.78±4.78	552.12±306	43.09±36	113305±97826	347±228	184 ±52	0.98±0.14

Spawning took place from the end of May (19 ºC) to the mid of July (25.8 ºC), according to monthly variations of GSI and egg diameter values. In similar studies, Yılmaz (2002) and Benzer et al. (2007) reported spawning period from late April to early July, in Porsuk Dam Lake and Hirfanlı Dam Lake, respectively. Other studies show slightly different periods and temperatures for spawning: O'maoileidigh and Bracken (1989) reported spawning from mid-June to the end of July in Ireland. Neophitou (1995) reported that spawning occurred during May and June at a water temperature of 18-20 ºC in Lake Pamvotida, Greece. Carral et al. (2003) and Alaş and Solak (2004) reported spawning between June and July (16.1 to 19.2 ºC). These comparisons reveal that tench populations, despite being geographically widespread, often spawn at similar times, and are likely to be under the influence of local environmental factors. For example, fish transferred from their native habitat to a new one often show some variations in spawning characteristics, presumably as a result of slight changes in ecology (Nikolsky, 1963).

In the present study, age at sexual maturity of male and female fish was III and IV years, respectively, which is similar to the results of Yılmaz (2002) and Alaş and Solak (2004). Neophitou (1995) and Benzer et al. (2007) reported that age of sexual maturity was III years for both sexes in Lake Pamvotida and Hirfanlı Dam Lake, respectively. In Ireland, tench in their third year, irrespective of sex, were still immature (O'maoileidigh and Bracken, 1989). Age of sexual maturity in tench may show variations in relation to water system, ecological characteristics and geographical location; spawning is often highly correlated with water temperature (O'maoileidigh and Bracken, 1989; Rodríguez et al., 2004).

The absolute fecundity of Lake Hirfanlı tench varied from 46115 ± 19213 to 308207 ± 75613 eggs/female, while mean relative fecundity was 347 ± 228 eggs mm^{-1} of fork length and 184 ± 52 eggs g^{-1} of total body weight. Absolute fecundity values ranged from 13,766 to 43,148 in Porsuk Dam Lake (Yılmaz, 2002) and from 12,088 to 37,150 in Hirfanlı Dam Lake (Benzer et al., 2007). Absolute fecundity of tench in Hirfanlı Dam Lake was found higher than in Porsuk Dam Lake (Yılmaz, 2002), in Hirfanlı Dam Lake (Benzer et al., 2007), in Kayaboğazı Dam Lake (Alaş and Solak, 2004), and in Ireland (O'maoileidigh and Bracken, 1989), being similar to that in Lake Patryki, Poland (Pimpicka,

1981) and Lake Drweckie, Poland (Pimpicka, 1991). Relative fecundity reported by Yılmaz (2002), varied from 57.60 to 132.36 mm^{-1} of average length and from 63.73 to 100.24 g^{-1} of average weight, and stated by Benzer et al. (2007), was in range of 47.40 - 116.82 mm^{-1} of average length and 40.29 - 56.03 g^{-1} of average weight. Relative fecundity value was found higher than in Porsuk Dam Lake (Yılmaz, 2002) and in Hirfanlı Dam Lake (Benzer et al., 2007), being similar to that in Lake Patryki (Pimpicka, 1981) and Lake Drweckie (Pimpicka, 1991). Fecundity was significantly correlated to fish length, weight, gonad weight and age as reported in many studies (Pimpicka, 1981 and 1991; Yılmaz, 2002; Türkmen et al., 2002; Alaş and Solak, 2004). Fecundity values may be correlated with factors such as fish age, size, health, egg diameter, population density, and a variety of environmental variables that affect the trophic status of a lake (Nikolsky, 1963). Any change in the environment (food supply, temperature, the amount of light, etc.) may result in significant changes in fecundity (Bagenal and Braum, 1978; Nikolsky, 1963).

Mean egg diameter in the spawning period was 0.98 ± 0.14 (SD) mm. Pinillos et al. (2003) reported that the diameter of mature oocytes was 0.7-0.8 mm in the spawning time, July. Mean egg diameter was reported as 0.9 mm in Lake Pamvotida (Neophitou, 1995). The egg radii were found to range between 0.4- 1.3 mm in Hirfanlı Dam Lake (Benzer et al., 2007). Egg diameter may be affected by fish size, gonad maturation stage and different parts of ovary as occurs in other species (Johnston and Leggett, 2002).

Fecundity-length, weight, gonad weight and age relationship parameters as logarithmic equations are given in Table 3 to compare the results of present study to different water bodies. The relationships between absolute fecundity and the parameters under study showed that absolute fecundity significantly correlated to length, body weight and gonad weight and almost linear relationship were found between them (see Table 3). These patterns were similar to the results of Pimpicka (1981 and 1991). In Ireland, regression coefficient showed that the relationship between total number of yolked eggs significantly correlated to total body weight (r= 0.91), fork length (r= 0.87) and total gonadal weight (r= 0.99) using a least squares regression analysis (O'maoileidigh and Bracken, 1989).

Table 3. Fecundity-length (L, cm), weight (W, g), gonad weight (GW, g) and age (t, year) relationship parameters of *T. tinca* in different habitats (∗: Length, mm)

Authority & Location	*n*	F-L relationship			F-W relationship			F-GW relationship			F-Age relationship		
		log *a*	*b*	r^2	log *a*	*b*	r^2	log *a*	*b*	r^2	log *a*	*b*	r^2
Pimpicka, 1981 Lake Patryki	43	0.229	3.323	0.654	1.547	1.252	0.701	3.447	0.869	0.803	3.791	1.763	0.431
Pimpicka, 1991	75	0.5872	3.0847		1.8176	1.1738		3.4387	0.9376		3.7742	1.8430	
Lake Drweckie	12	0.6606	3.0150		1.9157	1.1422		3.1145	1.2913		3.6772	1.9131	
	49	-0.8262	4.0430		0.8246	1.5295		3.5630	0.8789		3.8555	1.5313	
Alaş&Solak, 2004 ∗ Kayaboğazı Dam Lake		-2.1830	2.923	0.96	2.8899	0.792	0.97						
Present study Hirfanlı Dam Lake	24	-1.7423	4.5465	0.916	1.1445	1.4105	0.920	3.3322	1.0467	0.913	3.2421	2.6865	0.691

Conclusions

In the present study, tench showed higher fecundity than that of the results of the other studies carried out in Turkey. When the spawning time, first maturity age, fecundity, etc. were compared with the ones of Benzer et al. (2007) in Hirfanlı Dam Lake, the only spawning time showed similarity with this research. Curiously, over the course of the yearlong study, no tench were captured older than VI age group. This might indicate a size bias in Hirfanlı Dam Lake due to overfishing. However, since tench reach reproductive maturity at ages III-IV, this would not appear to negatively affect the population characteristics of the lake, meaning tench are not poached prior sexual maturity and off-season harvesting.

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