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Research Article

Some Biological Characteristics and the Stock Size of the Pike (*Esox lucius* L., 1758) Population in Lake Karamık (Afyon, Turkey)

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Abstract: Some biological characteristics and the stock size of the pike (*Esox lucius* L., 1758) population in Lake Karamık were investigated between March 2002 and February 2003.

The percentages of males and females in the population were 67.2% and 32.8%, respectively. Although fish samples ranged in age group from I to VII and from 15 to 66 cm in fork length, most of them were in age groups I-II and had fork lengths of 20-29 cm. The mean condition factor of the pike population was 0.812. In the population, the condition factors of females were higher than those of males. The condition factors of both sex groups increased with age. The total mortality, natural mortality and fishing mortality rates and the exploitation rate were Z = 1.28 year^{-1}, M = 0.19 year^{-1}, F = 1.09 year^{-1}, and E = 0.85 year^{-1}, respectively. The mean fish number over 15 cm in length in the population and their mean biomass were 295,836 individuals and 49,729 kg, respectively. It was determined that the present fishing effort should be decreased by 60% for maximum sustainable yield (42,273 kg).

Key Words: Pike, size composition, growth, mortality rate, stock

Karamık Gölü'ndeki (Afyon, Türkiye) Turna (*Esox lucius* L., 1758) Populasyonunun Bazı Biyolojik Özellikleri ve Stok Büyüklüğü

Özet: Mart 2002 ile Şubat 2003 tarihleri arasında yapılan bu çalışmada Karamık Gölü'ndeki turna balığı (*Esox lucius* L., 1758) populasyonunun bazı biyolojik özellikleri ve stok büyüklüğü incelenmiştir.

Populasyonun % 67,2'si erkek, % 32,8'i dişidir. Her ne kadar örneklerin yaşları I-VII, çatal boyları 15-66 cm arasında değişmekte ise de çoğunluğu I-II yaş gruplarında ve 20-29 cm arası boylardadır. Turna populasyonunun ortalama kondisyon faktörü 0,812 olarak bulunmuştur. Populasyonda, dişi bireylerin kondisyon faktörleri erkeklere göre daha yüksektir. Her iki eşey grubunun kondisyon faktörü de yaş ile artmıştır. Total ölüm, doğal ölüm ve balıkçılık ölümü oranları ile sömürülme oranı sırasıyla Z = 1,28 yıl^{-1}, M = 0,19 yıl^{-1}, F = 1,09 yıl^{-1} ve E = 0,85 yıl^{-1} olarak bulunmuştur. Turna balığı populasyonunda 15 cm'den büyük ortalama birey sayısı 295.836 ve onların ortalama biyoması 49.729 kg olarak tahmin edilmiştir. Maksimum sürdürülebilir ürün (42.273 kg) için mevcut av gücünün % 60 oranında azaltılması gerektiği belirlenmiştir.

Anahtar Sözcükler: Turna balığı, büyüklük kompozisyonu, büyüme, ölüm oranı, stok

Introduction

The pike (*Esox lucius* L., 1758) is widely distributed in Turkey and is one of the most valuable fish in fresh waters. They are large keystone piscivores and can tolerate a wide range of environmental conditions (1). This species is of high economic importance in the fisheries of Lake Karamık. Despite its importance, few studies have been conducted on the pike population in Lake Karamık (2-4). For sustainable fishery, fishing activities should be regulated perfectly. Therefore, the population structure, growth characteristics, reproduction, feeding, condition and stock size of fish populations in particular should be observed regularly. The aim of this study was to investigate some biological characteristics such as sex composition, size distribution, growth, condition, mortality rates and stock size of the pike population in Lake Karamık.

Materials and Methods

Lake Karamık is located southeast of the city of Afyon, in the west of the central Anatolia region of Turkey (Figure 1). The total surface area of the lake is 38 km^2, its mean depth is 2-3 m, and altitude is 1067 m. Most of the surface of the lake is covered by vegetation, and it is a eutrophic lake (5,6). Pike (*Esox lucius* L., 1758), carp (*Cyprinus carpio* L., 1758), *Alburnus orontis* (Sauvage, 1882), *Gambusia affinis* (Baird and Girard, 1853), *Cobitis turcica* (Hanko, 1924) and *Knipowitschia caucasica* (Berg, 1916) are present in Lake Karamık. Among these fish species, only pike and carp are important for commercial fishing, carried out using a total of 145 fishing boats.

Sampling studies were carried out at 3 different localities in the lake between March 2002 and February 2003. A total of 1097 fish samples were collected by gillnets of mesh sizes (length of stretched mesh) 36, 40, 44, 50, 60, 70, 80 and 90 mm, and trammel nets of mesh sizes 100, 120, 140 and 160 mm. The fork length (L ± 1 mm) and total weight (W ± 1 g) of each sample were recorded. Scale samples from each specimen were taken for age determination (7) by checking the scales. Catch and length-frequency distributions of pike caught by fishermen in a fishing season were determined to assess the stock size and total mortality (Z). In addition, water temperature was measured monthly throughout to use in the determination of natural mortality.

The length-weight relationship was determined using the least squares method (8):

$$W = a * L^b,$$

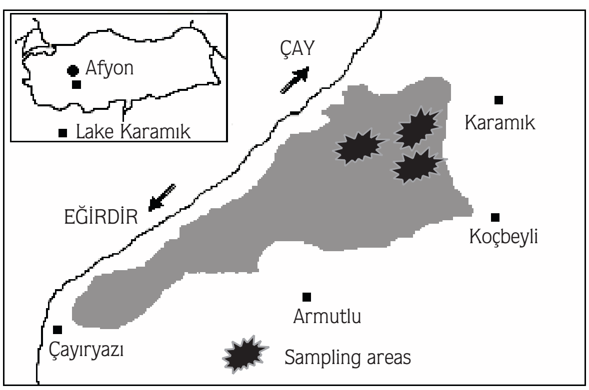

Figure 1. Map of Lake Karamık showing the sampling areas.

where W is the total body weight (g), L is the fork length (cm), and a and b are constants.

The von Bertalanffy growth equation was used to describe growth in length (9):

$$L_t = L_\infty * [1-e^{-K(t-t_0)}]$$

where L_t is the fork length (cm) of a fish at age t, L_∞ is the asymptotic length (cm), K is growth coefficient ($year^{-1}$), and t_0 is age (year) when L = 0.

Phi prime (ϕ') was calculated from Log (K) + 2 * Log (L_∞) (9) to compare the growths of different populations. The condition factors were determined using the formula $C = 100 * W/L^3$ (10).

Total mortality (Z) was calculated from linearized length-converted catch curve analysis (9,11). Pauly's emprical formula was used to determine natural mortality (9,12). Fishing mortality (F) and exploitation rate (E) were calculated from F = Z - M and E = F/Z. The percentage of surviving fish in 1 year (S), the percentages of fishing and natural mortality rates in the exploited stock were found with the following equations (9): $S = e^{-Z} * 100$, the percentage of natural mortality = (M/Z) * (100-S), the percentage of fishing mortality = (F/Z) * (100-S).

Pike stock was assessed using Jones' length-based cohort analysis (9,11). Maximum sustainable yield (MSY) and optimal effort were calculated using the Thompson and Bell model (9).

Differences between mean lengths, weights and condition factors in males and females within the same ages were tested by Student's t test, and difference between sex ratios was determined by chi-square test (13,14).

Results

Age and Growth

The ages of the samples ranged from I to VI for males and from I to VII for females. Males predominated in age group I and females in age groups I and II. Most of the samples were in the first age group (Figure 2). The rates of samples in the III and above age groups were rather low for both sexes. The percentages of males (737) and females (360) in the population were 67.2% and 32.8%, respectively. The ratio of males to females was 2.05:1 and the difference between the sexes was statistically significant (χ^2, P < 0.05).

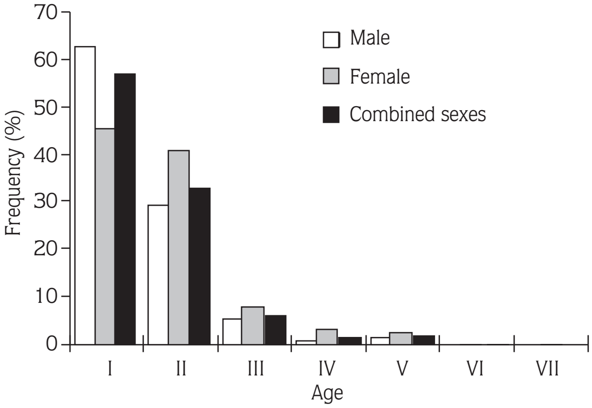

Figure 2. Age compositions of males and females and combined sexes of pike from Lake Karamık.

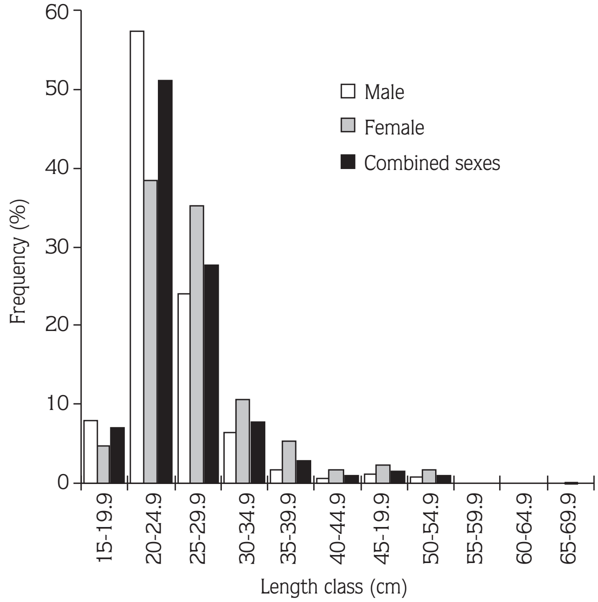

Figure 3. Length distributions of males, females and combined sexes for pike samples.

The length distributions of samples examined during this study are shown in Figure 3. The lengths of males and females were 15-54 cm and 15-66 cm, respectively. As shown in Figure 3, the majority of both sexes were between 20 and 29 cm. The rates of individuals over 40 cm in length were only 3.4% for the sexes combined.

The mean lengths and weights for each age group of males, females and combined are given in Table 1. The mean lengths and weights of females were higher than those of males in all age groups. However, the difference in length was statistically significant between males and females only in age group II. The differences in the mean weights of males and females in age groups I, II and V were statistically significant ($P < 0.05$), but they were not significant ($P > 0.05$) for the other age groups.

Age-Length Relationship

The von Bertalanffy growth equations in length of pike were calculated for males, females and combined as follows:

Males $L_t = 123.1 * (1-e^{-0.0899*(t+0.7424)})$

Females $L_t = 117 * (1-e^{-0.0981*(t+0.7352)})$

Combined sexes $L_t = 121.6 * (1-e^{-0.0921*(t+0.7469)})$

The ϕ' values of males, females and combined were 3.13, 3.12 and 3.13, respectively.

Table 1. The number (n), mean fork length ($\bar{L}$), weight ($\bar{W}$) and condition factor ($\bar{C}$) of pike in each age group for both sexes (SE: Standard Error).

		Age Groups				
Sexes		I	II	III	IV	V
Males	n	464	216	40	6	10
	$\bar{L}$ ± SE	22.2 ± 0.09	26.7 ± 0.17	35.2 ± 0.45	42.3 ± 1.80	49.5 ± 0.64
	$\bar{W}$ ± SE	89 ± 1.1	157 ± 3.1	349 ± 18.3	660 ± 92.5	1079 ± 52.6
	$\bar{C}$ ± SE	0.79 ± 0.003	0.81 ± 0.004	0.85 ± 0.015	0.84 ± 0.028	0.88 ± 0.016
Females	n	164	147	28	11	9
	$\bar{L}$ ± SE	22.5 ± 0.17	27.6 ± 0.20	35.9 ± 0.49	43.6 ± 1.37	50.4 ± 0.68
	$\bar{W}$ ± SE	93 ± 2.3	170 ± 4.1	356 ± 18.2	859 ± 76.7	1212 ± 48.3
	$\bar{C}$ ± SE	0.82 ± 0.006	0.83 ± 0.006	0.85 ± 0.013	0.91 ± 0.023	0.94 ± 0.030
Combined sexes	n	628	363	68	17	19
	$\bar{L}$ ± SE	22.3 ± 0.08	27.2 ± 0.13	35.5 ± 0.35	43.1 ± 1.07	50.0 ± 0.47
	$\bar{W}$ ± SE	91 ± 1.03	166 ± 2.5	370 ± 13.4	734 ± 59.3	1139 ± 37.9
	$\bar{C}$ ± SE	0.80 ± 0.003	0.82 ± 0.004	0.85 ± 0.010	0.87 ± 0.019	0.91 ± 0.017

Length-Weight Relationship

The equations of the length-weight relationships were as follows:

Males $W = 0.0063 * L^{3.0729}$

Females $W = 0.0060 * L^{3.0981}$

Combined sexes $W = 0.0059 * L^{3.0972}$

The slopes (b values) of the length-weight regressions did not differ significantly between the sexes (t-test; $P > 0.05$). Isometric growth was observed for pike in Lake Karamık, and the values of b for males and females were not significantly different from 3.0 (t-test; $P > 0.05$).

Condition Factor

The mean condition factors for each age group of males, females and combined are given in Table 1. The mean condition factors were 0.802 for males and 0.832 for females and 0.812 for the sexes combined. In the same age groups the differences between the mean condition factors of males and females of age groups I, II and III were statistically significant ($P < 0.05$), while they were not significant ($P > 0.05$) in the other age groups. It was determined that the mean condition factor increased with age for both sexes.

Mortality, Survival and Exploitation Rates

The total, natural and fishing mortality rates were 1.28 year^{-1}, 0.19 year^{-1} (T = 14 °C), 1.09 year^{-1} for pike larger than 15 cm in length, respectively. In addition, the mortality rates were 10.7% for natural mortality, 61.3% for fishing mortality and 72% for total mortality. The percentage of surviving fish in 1 year was 27.8%. The exploitation ratio was E = 0.85 year^{-1}.

Stock Size

The numbers of survivors are given according to length groups in Table 2. A total of 255,886 pike were recruited to the exploited stock when they were 15 cm in length. The number of survivors decreased gradually with increasing fish length and only 4008 of them reached 50 cm in length. The mean fish number, biomass and yield of cohort over 15 cm in each length interval are given in Table 3.

Table 3. Mean fish number, mean fish biomass and annual yield of pike over 15 cm by length intervals.

Length Interval	Mean Fish Number	Mean Biomass kg	Yield kg
L_1-L_2	$\bar{N}_{(L1,L2)} * \Delta t$	$\bar{B} * \Delta t$	$Y_{(L1,L2)}$
15-19.9	123,362	5152	609
20-24.9	86,334	7853	9213
25-29.9	39,097	6621	9440
30-34.9	16,652	4731	4451
35-39.9	9269	4102	2499
40-44.9	6317	4119	1188
45-49.9	4258	3919	2683
50-∞	10,548	13,234	2514
Total	295,836	49,729	32,598

Bioeconomical Analysis of Pike Stock

With the present fishing effort, the yield was 32,598 kg and the mean biomass was 49,729 kg. The yield and biomass are shown in Figure 4 for different levels of fishing effort. These results showed that if the present fishing pressure was decreased by 60%, the yield could be increased to 42,273 kg.

Table 2. The calculation procedure of Jones' length-based cohort (K = 0.0921 year^{-1}, L_∞ = 121.6 cm, M = 0.19 year^{-1}, the asterisk indicates terminal F/Z (assumed to be 0.500)).

Length Interval	Catch Survivor									
L_1-L_2	N	$t_{(L1)}$	Δ_t	$\bar{W}$	$H_{(L1,L2)}$	$N_{(L1,L2)}$	$N_{(L1)}$	F/Z	F	Z
15-19.9	80	1.429	0.522	0.042	1.0508	14,575	255,886	0.383	0.118	0.308
20-24.9	556	1.951	0.548	0.091	1.0534	101,296	217,872	0.861	1.173	1.363
25-29.9	306	2.499	0.577	0.169	1.0564	55,749	100,173	0.882	1.426	1.616
30-34.9	86	3.076	0.609	0.284	1.0596	15,668	36,995	0.832	0.941	1.131
35-39.9	31	3.686	0.646	0.443	1.0633	5648	18,143	0.762	0.609	0.799
40-44.9	10	4.331	0.687	0.652	1.0674	1822	10,754	0.603	0.288	0.478
45-49.9	16	5.018	0.733	0.920	1.0721	2915	7732	0.783	0.685	0.875
50-∞	11	5.751		1.255		2004	4008	*0.500	0.190	0.380

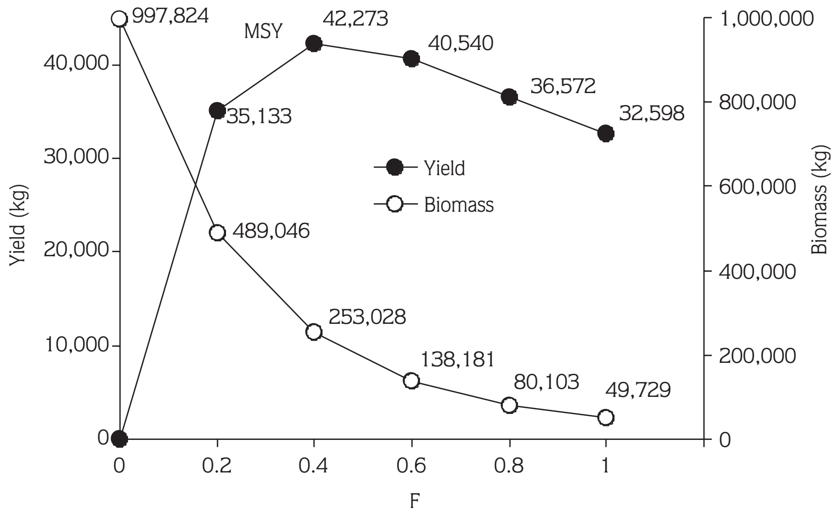

Figure 4. Prediction of yield-biomass relationships at various fishing effort levels.

Discussion

The sex rate in most species is close to 1 (15). In this study, the rate of males to females was rather high (2.05:1). The sex rate may vary temporally and spatially. This variation may partly reflect different availabilities or catchabilities resulting from sexual differences in behavior that change seasonally (e.g., during the spawning period) (16). During this study, the rate of males to females caught in the spawning season (in February and March) was higher than in the other months (3.64:1). Males may be more active than females in this period. This rate was reported as 1.30:1 (male/female) by Aksun (2) for the pike population in the same lake about 20 years ago. This difference was probably due to the sampling being performed in the spawning period. The rate of male pike was higher than that of females in Lake Trasimeno in Italy (17) and in Kesikköprü Dam Lake (18), while it was lower in Lake Işıklı (19) and in an Irish reservoir (20).

The maximum age was VI for males and VII for females. These ages were lower than the values reported by Roche et al. (20) in an Irish reservoir and by Griffiths et al. (21) in a northern Ontario river, but higher than the values reported by Altındağ et al. (18) in Kesikköprü Dam Lake. Both males and females predominated in the younger ages and the rate of individuals older than II decreased sharply from age group II to III in both sexes. Only 8.7% of the samples were age III or above. The fork length of samples examined in this study ranged from 15 to 66 cm and almost 51% of them were between 20 and 24 cm in length. The minimum fishing size for this species in all fresh waters of Turkey is 40 cm in terms of total length (22), which is equal to 38 cm fork length. In this study, the rate of pike over 38 cm in fork length was rather low.

The mean lengths and weights of females were higher than those of males in all age groups. The parameter values of the von Bertalanffy equation were $L_\infty = 121.6$ cm, $K = 0.0921$ year^{-1} and $t_0 = -0.07469$ year for the sexes combined. The growth parameters of males and females ($L_\infty = 123.1$ cm, $K = 0.0890$ year^{-1} $t_0 = -0.7424$ year for males and $L_\infty = 117$ cm, $K = 0.0981$ year^{-1}, $t_0 = -0.7352$ year for females) were close to each other. According to Sparre and Venema (9), ϕ' is the best index of overall growth performance, in the sense that it has minimum variance. In this study, the value of ϕ' for the pike population in Lake Karamık was 3.13. This value was higher than that reported by Aksun (2) for the pike population in the same lake about 20 years ago. In addition, this ϕ' value was higher than those reported by Griffiths et al. (21) in a northern Ontario river and by Altındağ et al. (18) in Kesikköprü Dam Lake, but lower than that reported by Lorenzoni et al. (17) in Lake Trasimeno in Italy. These differences in growth performance among the lakes can be attributed to differences in the size of the largest individuals sampled. In addition, growth is affected by ecological factors such as food abundance and temperature in different lakes.

The slope values (b = 3.0729 for males and b = 3.0981 for females and b = 3.0972 for the sexes combined) of the length-weight relationships showed that growth was isometric. Lorenzoni et al. (17), Roche et al. (20) and Griffiths et al. (21) reported similar results in Lake Trasimeno, in an Irish reservoir and in a northern Ontario river, respectively. However, lower values were reported by Altındağ et al. (18) in Kesikköprü Dam Lake and by Çubuk et al. (23) in Lake Uluabat. According to Tesch (24), the b value in each fish population may differ according to species, sex, age, season and feeding.

The mean condition factor was 0.812. This value was higher than that of the Lake Uluabat (23) pike population, but lower than those of Lake Işıklı (19), Lake Mogan (25) and Kesikköprü Dam Lake (18). The condition factor increased gradually with age for both sexes. In addition, the condition factors of females in all age groups except for age group III were higher than those of males. According to Le Cren (8) and Ricker (10), the condition factor exhibits changes depending on gonad development, age, seasonal changes in growth and net mesh size.

Mortality rates are important for understanding the rate of population decay (9,10). The total mortality rate was rather high (72%) for the pike population in Lake Karamık. In addition, the exploitation rate is an index of fishing levels. Gulland (26) suggested that it should be E = 0.50 for maximum sustainable fishing. However, the exploitation rate was E = 0.85 year^{-1} for the pike population in Lake Karamık. The mortality and exploitation rates seem to be a threat to the population in the future.

During the study, the annual yield of pike was 32,598 kg. The stock of pike over 15 cm in length was estimated as 295,836 individuals and 49,729 kg in biomass. It was determined from the stock analysis that if the present fishing effort was decreased by 60%, 42,273 kg yield would be obtained from the pike population in Lake Karamık.

Consequently, it is clear from age and length compositions, mortality rates, exploitation rate and bioeconomical analysis of stock that the pike population in Lake Karamık has been overexploited. For maximum sustainable yield, the number of fishing boats should be decreased from 145 to about 58-60 boats.

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