

Changes in the Population Structure of Pikeperch (*Sander lucioperca* Linnaeus, 1758) Karacaoren-I Dam Lake, Turkey

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Abstract: This study was conducted between November 2008 and October 2009 and examined changes in the population structure of pikeperch (*Sander lucioperca* L., 1758) in Karacaoren-I Dam lake, located in Turkey. About 37.2% of the 113 pikeperch individuals caught were found to be female and 62.8% were male. When the age distribution was analyzed, 1 and 5 year old age groups were seen to constitute the majority of the population. It was observed that fork lengths differ between 19.7 and 68 cm and body weights differ between 77.5 and 3472.9 g. Stomach contents were analyzed and mostly (89.41%) consisted of sand smelt (*Atherina boyeri* Risso, 1810). The average condition factor value of the pikeperch caught in Karacaoren-I Dam lake was found 1.001. A serious decrease in the pikeperch population was noted in this lake, similar to other lakes. Moreover, it was seen that the balance in the lake has changed over approximately the last 10 years and that species detected in previous studies have been replaced by other species.

Key words: Pikeperch, *Sander lucioperca*, population structure, Karacaoren-I Dam lake, Burdur, Turkey

INTRODUCTION

Pikeperch (*Sander lucioperca* L., 1758) is a species of fish originating from Europe which was introduced to Turkey in the 1950s. Pikeperch is consumed widely and has a high economic value. Pikeperch was first introduced to Turkey at Egirdir lake but was later introduced to other lakes within Turkey. However, except for the studies by Balik and Cubuk no comprehensive study of pikeperch has been carried out in Karacaoren-I Dam lake which was built in 1990. Carnivorous/omnivorous balance should be well established and should be maintained in the inland waters of Turkey where planned fishing cannot be applied.

The aim of this study was to identify any changes in the population structure of pikeperch which has been economically fished in Karacaoren-I Dam lake for the last 10 years. Table 1 shows the fish yields from Karacaoren-I Dam lake between 1998 and 2009, according to data from the Burdur Provincial Directorate of Agriculture.

One particularly conspicuous finding from the annual data is that the pikeperch yield of 20,460 kg in 2004 subsequently fell to 50 kg in 2009. Data obtained from the present study were compared with the findings of previous studies carried out in this lake. Moreover, considering the reasons for the serious decrease in the

Table 1: Fish yields from Karacaoren-I Dam lake, 1998-2009 (kg)

Years	<i>C. carpio</i>	<i>S. lucioperca</i>	<i>C. gibelio</i>	Fish yields (kg)
1998	2771	13611	-	16382
1999	4405	2676	-	7081
2000	6021	3537	-	9558
2001	1613	320	-	1933
2002	300	6000	9000	15300
2003	400	4400	5600	10400
2004	1834	20360	6035	28229
2005	2700	10714	6190	19604
2006	1200	16207	9287	26694
2007	760	3721	2350	6831
2008	1678	1000	245	2923
2009	3352	50	1355	4787

fish stocks we tried to determine appropriate measures to allow the sustainable fishing of pikeperch and other species in Karacaoren-I Dam lake.

MATERIALS AND METHODS

Karacaoren-I Dam lake is located in the cities of Isparta and Burdur and the fish fauna of the lake is comprised of the fish species found in Aksu stream, Kovada canal and Goksu river. This study investigated changes in the population structure of pikeperch (*S. lucioperca* L., 1758) in Karacaoren-I Dam lake; the study was carried out between November 2008 and October 2009.

The sampling method used gill nets (200 m long by 2 m high) with mesh sizes of 20, 40, 60 and 80 mm. Samples were taken monthly at Elsazi, Kizilli and Candir stations in

Karacaoren-I Dam lake. However, the gill net sampling produced insufficient quantities of pikeperch to conduct the study, so the remaining amount was supplied by the fishermen of Elsazi-Kizilli-Karacaoren Fishing Cooperative, fishing in this lake. Fork lengths (FL, cm) and body weights (W, g) of the pikeperch individuals caught (n = 113) were measured. Their ages were determined by examining their scales (Chugunova, 1963).

The formula $G_{FL} = (\text{Log}_e(FL_{t+1}) - \text{Log}_e(FL_t)) / \Delta t$ was used to measure the specific increase in fish length among the age groups of the pikeperch individuals. The formula $G_w = (\text{Log}_e(W_{t+1}) - \text{Log}_e(W_t)) / \Delta t$ was used to measure the specific increase in weight (Weatherley and Rogers, 1978). The equation $\text{Log}W = \text{Log}a + b * \text{Log}FL$ was used to measure the length/weight relationship. Length/weight relationship was determined according to ages with Fulton's condition factor ($KF = W/FL^3 \times 100$) which is based on isometric growth (Busacker *et al.*, 1990). Statistical analysis of the data used the t-test and χ^2 -test and a significance level of $p = 0.05$ was used.

RESULTS AND DISCUSSION

Fish populations in Karacaoren-I Dam lakes: The present study found *S. lucioperca* L., 1758, *Cyprinus carpio* L., 1758, *Carassius gibelio* Bloch, 1782, *Oncorhynchus mykiss* Walbaum, 1792 and *Carassius auratus* L., 1758 in Karacaoren-I Dam lake. It was seen during field work that there are plenty of *Atherina boyeri* Risso, 1810 in the lake. Compared with the fish species reported in previous studies, the following species were not sampled in the present study: *Capoeta pestai* Pietschmann, 1933, *Luciobarbus pectoralis* Heckel, 1843, *Vimba vimba* L., 1758, *Capoeta antalyensis* Battalgil, 1943, *Pseudorasbora parva* Temminck and Schlegel, 1846, *Gambusia affinis* Baird and Girard, 1853, *Knipowitschia caucasica* Berg, 1916 and *Anguilla anguilla* L., 1758.

Age and sex distribution: Ages varied in this study between 1-4 years and I (39.9%) and 5 year old (28.3%) age groups represented the majority of the population. Pikeperch individuals had an age distribution between 1-4 years of age, 37.2% of the population was female and 62.8% was male (Fig. 1). It was found that 1 year old and 5 year old individuals combined represented 67.2 % of the population. Compared with previous studies, the percentage of individuals in the 0 (26.67%) and 1 year old (26.15%) age groups were found to be higher in the study carried out by Becer (1999) and the percentage of individuals between the ages 1-3 (78%) was higher in the study carried out by Balik and Cubuk. Becer and Balik and Cubuk reported the percentage of the population older than 3 years as 12.48 and 13.6%, respectively, compared with 47.78% in the present study.

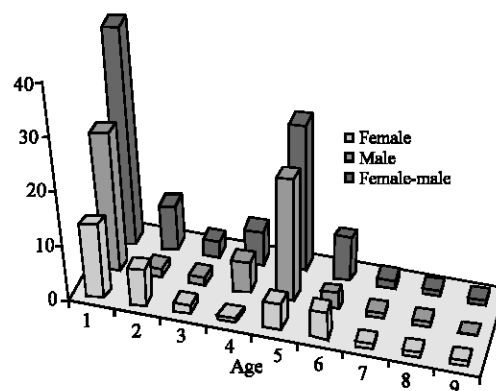


Fig. 1: Age and sex distribution of pikeperch population

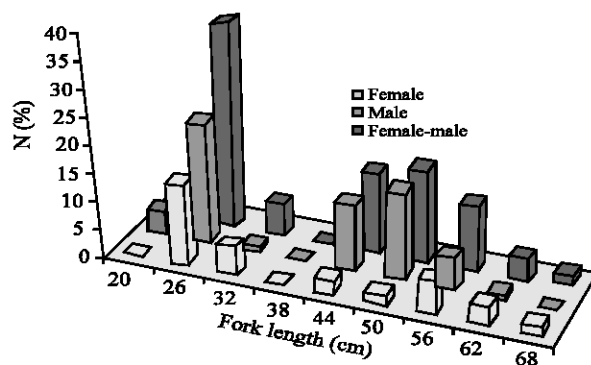


Fig. 2: Length distribution of pikeperch population

The ratio of the females to the males in the population was 1:1.69. When the difference between the sexes according to the age groups is examined, it was observed that the difference between 4 and 5 year old age groups was statistically significant ($p < 0.05$) but it was not important in the other age groups.

Length distribution: The fork lengths of the pikeperch samples ranged between 19.7 and 68 cm (Fig. 2). While the fork lengths of female individuals were between 23.4 and 68 cm, the fork lengths of male individuals were between 19.7 and 62.9 cm. It was observed that 45.12% of the population was comprised of individuals in the length group 44-56 cm, 37.17% of the population was comprised of individuals in the length group 26 cm and remaining length groups represented 17.71% of the population.

Weight distribution: The weights of the pikeperch samples varied between 77.5 and 3472.9 g (Fig. 3). While the weight of female individuals varied between 124.8 and 3472.9 g, the weight of male individuals varied between 77.5 and 2684.6 g. It was observed that 48.67% of the population was composed of individuals in the weight group 200 g, 0.69% of the population was composed of

the individuals in the weight group of 1000-1800 g and the remaining weight groups represented 10.64% of the population.

Growth in length and weight: Table 2 shows specific values for increases in length and weight according to age group. The results show that the maximum increase of 0.344 occurs between 2 and 3 year old age groups and the minimum increase of 0.038 occurs between 8-9 year old age groups; specific values for increase in length generally decrease with increasing age.

It is seen from the measurements according to the average weight values for each of the age groups of pikeperch individuals that this ratio reaches its maximum with 1.059 between 2 and 3 year old age groups, reaches its minimum with 0.161 between 6-7 year old age groups and specific values of increase in weight decrease together with age in general. The overall average condition factor value of sander group was found to be 1.001.

The length-weight relationship in the pikeperch population was examined logarithmically and exponentially by subjecting all of the individual data to linear regression analysis. The length-weight equation for the sample was found to be: $\log W = -2.182 + 3.112 \log FL$ ($r = 0.996$) (Fig. 4).

The present study examined changes in the population structure of pikeperch (*Sander lucioperca* L., 1758) in Karacaoren-I Dam lake. Comparison of the present results with the findings of Cubuk and Balik and Becer indicated a serious decrease in the pikeperch population and it was determined that individuals that are bigger (terms of length, weight and age) and have higher condition factor represent the largest proportion

of the population in terms of the age, length and weight. A decrease in the ratio of females and an increase in the ratio of males were observed. Moreover, when the results of the present study are compared with those of a study carried out 10 years ago in Karacaoren-I Dam lake, it can be seen that growth in length according to ages has

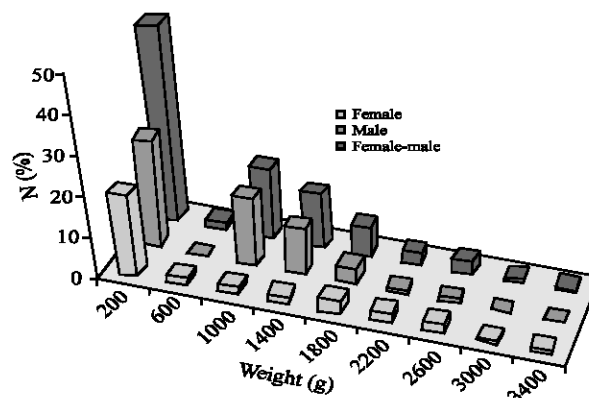


Fig. 3: Weight distribution of pikeperch population

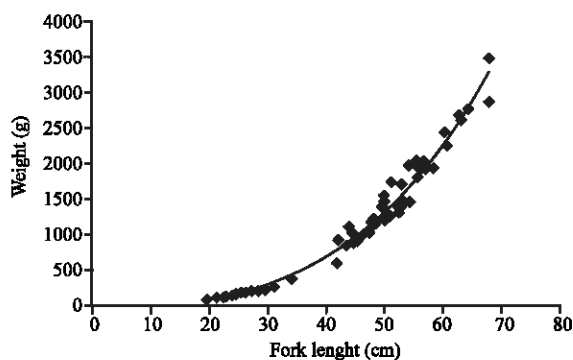


Fig. 4: Length-weight relationship of all pikeperch population

Table 2: Specific growth and condition factor values of pikeperch population according to ages

Age	N	FL±SE (cm) (Min.-Max.)	GF	W±SE (g) (Min.-Max.)	GW	KF±SE (Min.-Max.)
I	45	25.93±0.25 (19.70-28.80)	0.156	173.72±4.82 (77.50-222.98)	0.346	0.987±0.009 (0.880-1.091)
II	10	30.30±0.55 (28.6-34.3)	0.344	245.56±13.16 (204.60-347.35)	1.059	0.878±0.018 (0.796-0.997)
III	4	42.75±0.52 (41.7-43.7)	0.076	708.19±71.31 (567.58-838.6)	0.339	0.898±0.058 (0.783-1.005)
IV	8	46.12±0.87 (44-50.5)	0.083	993.38±48.28 (861.2-1201.1)	0.304	1.012±0.040 (0.932-1.289)
V	32	50.13±0.69 (42.3-56.8)	0.126	1346.43 ±62.49 (878-2024)	0.385	1.048±0.019 (0.902-1.278)
VI	9	56.88±1.49 (50.3-63.3)	0.068	1979.25±149.40 (1176.2-2621.1)	0.161	1.060±0.029 (0.924-1.190)
VII	2	60.85±3.84 (57-64.7)	0.073	2325.25±449.74 (1875.6-2775.1)	0.174	1.02±0.01 (1.013-1.025)
VIII	2	65.45±2.54 (62.9-68)	0.038	2767±82.39 (2684.6-2849.4)	0.227	0.99±0.08 (0.906-1.079)
IX	1	68		3472.9		1.105

Table 3: Length and weight values of pikeperch in different years in Karacaoren I-Dam lake

		Age								
Researcher	Parameter	I	II	III	IV	V	VI	VII	VIII	IX
Becer (1999)	FL	24.69	30.10	35.40*	39.76*	47.03*	50.70*	54.81*	60.26*	-
	W	134.67	251.40	411.44	616.53	1022.53	1334.50	1700.27	2329.66	-
This study	FL	25.93	30.30	42.75	46.12	50.13	56.88	60.85	65.45	68
(2009)	W	173.72	245.56	708.19	993.38	1346.43	1979.25	2325.25	2767.00	3472.9

*p<0.05

greatly increased, especially after III years of age. The difference between length values determined in the same lake at different times was statistically significant ($p < 0.05$) after III years of age (Table 3). This difference between the two studies is thought to indicate an advantageous environment for older pikeperch individuals, resulting from changes in the pikeperch food chain associated with fishing methods and changes in fish species diversity over time.

Compared with other habitats fork length according to age, the pikeperch population of Ijssel lake and Taivassalo lake have been characterised to reach a length of 14 and 19 cm after the end of the first growth season, respectively (Willemsen, 1983; Lehtonen, 1983).

Stomach contents: The stomach contents of 87 of the 113 pikeperch individuals in this study were examined. It was observed that the stomachs of 61 individuals were empty and the stomachs of 26 individuals were full. The full stomach contents were analyzed in terms of prey fish and consisted of 89.41% *A. boyeri*, 8.23% *C. gibelio* and 2.36% other organisms. The individuals examined were not found to exhibit the characteristics of cannibalism. It was observed that as the lengths of the pikeperch increased, so did the lengths of the fish they ate in general; pikeperch of lengths of up to 50 cm prefer sand smelt and the individuals longer than 50 cm prefer silver crucian carp. Average lengths of the prey fish in the stomachs of the pikeperch individuals are shown in Table 4.

Adult pikeperch are able to utilize a large variety of prey fish species (Winkler, 1991). The mean length of prey fish of pikeperch in the Volga Delta (Popova and Sytina, 1977) and in lake IJssel (Willemsen, 1977) increased gradually with predator size (Van Densen, 1994). Prey fish first began to appear in the stomachs of pikeperch (with an average length of 19.5 cm) in a study conducted by Becer Ozvarol. Above this length, young pikeperch in the 0 year old age group and particularly *V.v. tenella* and *C. carassius* were found in all length groups.

When the stomach contents of pikeperch were examined in this study, prey fish species were found to be 89.41% sand smelt (*A. boyeri*) which recently entered the lake and 8.23% silver crucian carp (*C. carassius*).

It is thought that the pikeperch that grow large enough to consume those two species which are dominant in the lake do not suffer from food shortage and the resulting abundance of food results in better feeding and higher condition factor value among older and larger pikeperch. Moreover, in contrast to the findings reported Becer Ozvarol, the present study found no evidence of cannibalism among pikeperch; *A. boyeri* became the main food of pikeperch instead of *V.v. tenella* which was

Table 4: Length distribution of prey fish in the stomachs of pikeperch

Prey FL (cm)	Pikeperch length (cm)			
	20-30	30-40	40-50	50-70
<i>A. boyeri</i>	3.41	4.66	5.95	-
<i>C. gibelio</i>	-	-	-	14.8

found intensely in the lake approximately 10 years ago and thus the diet of pikeperch changed according to the new species in the Lake Bream.

The species of fish in Karacaoren-I Dam lake has changed in the past 10 years. It was observed that carp (*C. carpio*) which was previously the dominant species (59.9%) in the lake, decreased despite fish planting applications sand smelt (*A. boyeri*) which entered the lake belatedly and silver crucian carp (*C. gibelio*) have an important role in the population. Moreover, it is estimated that density of the populations of vimba (*V. vimba*), Antalya barb (*C. antalyensis*), European eel (*A. anguilla*), barbel fish (*L. pectoralis*) and Egirdir barb (*C. pestai*) decreased seriously. In this study, pikeperch (*S. lucioperca*), carp (*C. carpio*), silver crucian carp (*C. gibelio*), rainbow trout (fleeing from fish farms to the lake) (*O. mykiss*), Prussian carp (*C. auratus*) and plenty of sand smelt (*A. boyeri*) were found to be present in Karacaoren-I Dam lake. It was observed that over time, silver crucian carp and sand smelt replaced carp which was previously reported to be dominant in the lake by Cubuk and Balik, sand smelt and rainbow trout which escaped from fish farms to the lake, now compete with pikeperch which was previously the only fish-predator species in the lake. These findings demonstrate why the conditions of the fish populations in Karacaoren-I Dam lake and the ratio of carnivorous/omnivorous species should be determined and constantly monitored.

The fisheries and aquaculture sector, together with the yield increased on the basis of production potential, contributes to the economy of the country (Yilmaz and Yilmaz, 2009). However, several factors, including insufficient fisheries planning for inland waters, inappropriate fish transplantations without considering the limnological structures of lakes, result in declining fish production and the extinction of native species.

Fish transplantation projects in the Karacaoren-I Dam lake are carried out under the responsibility of the XVIII. regional directorate for state hydraulic works in order to increase the carp population. However, while large numbers of carp are regularly introduced to the lake, it is clear that the ecological balance of the lake has changed as demonstrated by declining fish yields and population instability. It is conspicuous that silver crucian carp and sand smelt impose stress on rival species in the food chain and as a result, influence the declining fish yields.

CONCLUSION

Karacaoren-I Dams lake and Egirdir lake are connected and therefore have a high potential to influence each other ecologically and limnologically. Most of the fish species in Karacaoren-I Dam lake have their origins in Egirdir lake. Thus, as there is a connection between those lakes, it should be considered that Karacaoren-I Dam lake will also be affected by fish transplantation projects in Egirdir lake. Sand smelt which has become a dominant species in Karacaoren-I Dam lake is hardly fished and silver crucian carp is not preferred, as the taste is inferior to carp and pikeperch. The continued existence of pikeperch in the lake is important not only in terms of economic benefits but also in terms of the carnivorous/omnivorous balance. It should be considered that large pikeperch will be necessary to control those two dominant species in Karacaoren-I Dam lake and that fishing of pikeperch in Karacaoren-I Dam lake should be forbidden until the desired balance is established.

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