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Research Article

Some Growth Parameters of Five Fish Species in the Lower Sakarya River, Turkey

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ABSTRACT

In this study, a total of 1283 samples of five fish species belonging to two families, Cyprinidae and Leuciscidae, were collected from the Lower Sakarya River between June 2017 and May 2018 in order to determine some growth parameters.The samples were collected monthly with trammel net, fykenets, and electro shocker. The age of the fish was determined from the scales. The von Bertalanffy's growth model was calculated Lt = 92.18(1-e$^{-0.054(t+0.040)}$) for *A. brama*, Lt = 69.40(1-e$^{-0.040(t+0.030)}$) for *B. bjoerkna*, Lt = 51.09(1-e$^{-0.114(t+0.024)}$) for *C. gibelio*, Lt = 48.11(1-e$^{-0.088(t+0.023)}$) for *R. rutilus* and Lt = 41.74(1-e$^{-0.104(t+0.035)}$) for *V. vimba*. The phi-prime growth performance index (Φ') value was computed as 2.628, 2.268, 2.474, 2.307 and 2.260 for *A. brama, B. bjoerkna, C. gibelio, R. rutilus* and *V. vimba*, respectively. This study provides basic information on some growth parameters of five fish species living in the Lower Sakarya River. The results of this study are useful for fishery managements and stock assessment in the Sakarya River.

Keywords: Age and growth, cyprinidae, leuciscidae, fishery management, Sakarya River

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INTRODUCTION

Rivers and natural lakes are important ecosystems of our world and cover approximately 2.5% of the earth's surface (Shiklomanov, 1999). Turkey has important freshwater resources and one of these freshwater resources is the Sakarya River. The Sakarya River basin (58000 km^2), one of the majör rivers pouring into the Black Sea, covers approximately 7 % of Turkey's surface area (783000 km^2). Its average flow rate is about 190 m^3 per second. The water temperature changes between 7 to 24 °C through out the year. The river basin is divided into three regions named Lower, Mid and Upper Basin (Şengörür & İsa, 2001).

Cyprinidae is found in North America (from northern Canada to southern Mexico), Africa, and Eurasia. Cyprinidae is the largest family of freshwater fish with 346 genera and 3,170 species in the world. Leuciscidae is the other important freshwater fish with 90 genera and 672 species (Eschmeyer, Fricke & van der Laan, 2017). Various researches have been carried out on the fish species living in the Sakarya River and its tributaries. (Ölmez, 1992; Emiroğlu, 2011; Kahraman, Göktürk & Aydın, 2014; Korkmaz & Zencir Tanır, 2016; Memiş, Tosun, Yamaner, Tunçelli & Gessner, 2019; Reis, Cerim & Ateş, 2019).

Age and growth are related with each other. Age gives a knowledge about sexual maturity, spawning period, fish size, growth rate and lifespan. Knowledge of all these parameters are important data for fisheries management and vary among populations. Accurate age determination and estimates of growth parameters are fundamental requirements for understanding population dynamics and maintaining sustainable yields in fisheries biology (Campana & Thorrold, 2001).

In this study, some growth parameters were determined for *Abramis brama* (Linnaeus, 1758),

Blicca bjoerkna (Linnaeus, 1758), *Carassius gibelio* (Bloch, 1782), *Rutilus rutilus* (Linnaeus, 1758) and *Vimba vimba* (Linnaeus, 1758) that were caught in the lower Sakarya River. These datas contribute to the sustainable management of the Sakarya River fisheries.

MATERIALS AND METHODS

This study was carried out between June 2017 and May 2018 in the 159.5 km section of the Sakarya River within the borders of Sakarya province. The aforementioned section includes Mekece in the south of Pamukova and Karasu Yenimahalle, where it deposits into the Black Sea.

The samples were collected monthly with trammel nets (inner panel: 52-72-88 mm, outer panel: 300 mm; stretched mesh sized), fyke net (140 mm stretched mesh sized, 5 m leader net) and electro shocker (SAMUS 1000; 500W) from the three stations (Pamukova, Adapazarı and Karasu) identified in the lower Sakarya River Basin (Figure 1). The sampling areas were sandy-muddy substrates and depths were between 1.5-10 meters.

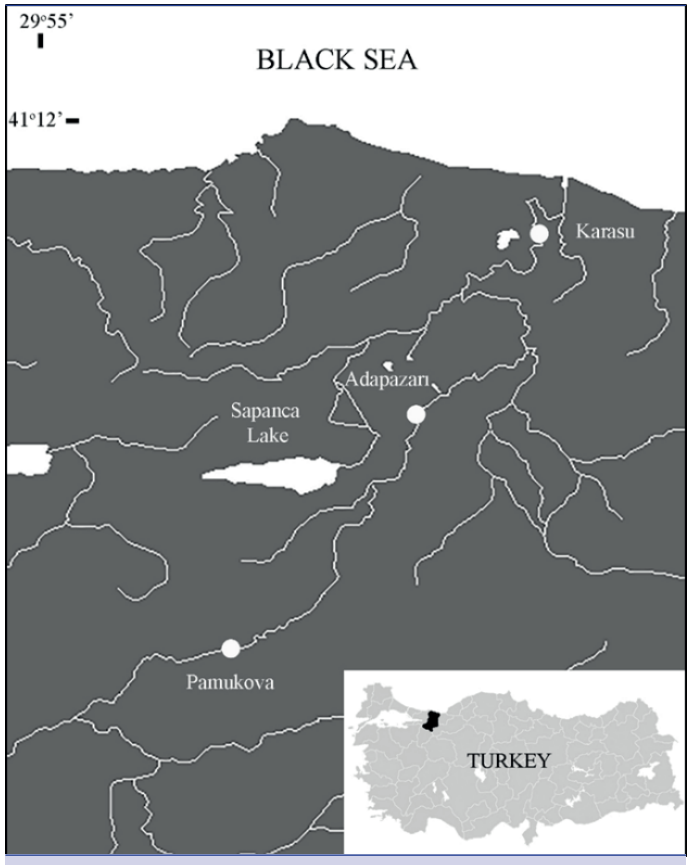

Figure 1. Study area.

The samples were brought to the laboratory and the fish species were determined according to their diagnostic characteristics (Kottelat & Freyhof, 2007). Total lengths and weights of samples were measured with measuring boards (0.1 cm) and precision balance (0.01 g). Scales were used to determine the age of the fish. The scales were taken from the area between the dorsalfin and the lateral line on the left side of the fish by forceps and placed in numbered envelopes (Lagler, 1966). Scales were removed from the envelopes and placed in petri dishes, containing 3% NaOH solution, in order to be purified from foreign bodies. Randomly selected scales were examined under a binocular microscope (Chugunova, 1963).

Growth parameters were investigated by applying the von Bertalanffy growth function. The von Bertalanffy growth function was calculated as follows: $L_t = L_\infty (1\text{-}e^{-k(t\text{-}to)})$ (von Bertalanffy, 1957), where L_t is length at age t, L_∞ is asymptotic length, k is the growth coefficient, and t_0 is the hypothetical age at which length is equal to zero (Ricker, 1975).

The growth performance index was calculated by the equation of Pauly & Munro (1984):

$\phi' = Log\ k + 2\ Log\ L\infty$

RESULTS AND DISCUSSION

In this study, all samples were analyzed to estimate age and growth parameters, including five fish species from the Lower Sakarya River, Turkey. The parameters shown in Table 1 included sample size (n), range of total length (TL) and body weight (W), and standard error (SE).

The von Bertalanffy's growth model was calculated $Lt = 92.18(1\text{-}e^{-0.054(t+0.040)})$ for *A. brama*, $Lt = 69.40(1\text{-}e^{-0.040(t+0.030)})$ for *B. bjoerkna*, $Lt = 51.09(1\text{-}e^{-0.114(t+0.024)})$ for *C. gibelio*, $Lt = 48.11(1\text{-}e^{-0.088(t+0.023)})$ for *R. rutilus* and $Lt = 41.74(1\text{-}e^{-0.104(t+0.035)})$ for *V. vimba*. The asymptotic length ($L\infty$), growth coefficient (k), hypothetical age (t_0) and growth performance index (ϕ') were shown in Table 2.

This study is the first assessment of the age and growth of *A. brama, B. bjoerkna, C. gibelio, R. rutilus* and *V. vimba* in the lower Sakarya River. The growth parameters ($L\infty$, K, t_0, ϕ') studied by different authors are given from other water areas (Table 3).

It was determined that the age composition of *A. brama* individual sex tend to 2^+-9^+ages. The age composition results of different researches were given in Table 4 for *A. brama.* Asymptotic length value was higher when compared to previous studies for *A. brama* (Table 3). In contrast, k value is lower than other studies. According to the growth performance index results, it can be said that *A. brama* showed average development in conditions of the lower Sakarya River.

The maximum age of *B. bjoerkna* in this study was 10^+ years which is higher than that of reported studies in Table 4. These differences may be due to the variations in sampling method and period, potential aging errors, and overfishing. The $L\infty$ value obtained in this study was higher than that in earlier researches. In the present study, the k value was found to be lower than that found by other researchers (Table 3). Ma, Xie, Huo, Yang & Huang,(2010) reported that different size distributions in different study may be the causes of differences among all of the estimated parameters.

The age composition of *C. gibelio* individuals was between 1^+-7^+ in the present study. Some differences were observed in age groups of *C. gibelio* when compared to previous researches

Table 1. Mean total length (ML. cm). mean weight (W. g). number of sample (n) and standard error (SE) for different age groups of five fish species.

		Age									
		1+	2+	3+	4+	5+	6+	7+	8+	9+	10+
A. brama	n		5	14	37	55	17	8	2	3	
	ML±SE		18.3±2.32	21.2±1.30	24.6±1.88	30.0±1.17	33.1±0.73	36.1±1.75	39.1±0.51	41.4±1.16	
			(14.3-20.3)	(19.1-23.5)	(21.1-28.0)	(26.7-31.9)	(31.8-34.6)	(34.1-39.6)	(38.8-39.5)	(40.3-42.6)	
	MW±SE		66.92±20.21	104.64±23.91	167.60±38.44	299.39±46.61	416.40±53.25	560.22±73.34	762.81±20.49	872.23±45.03	
			(33.35-87.52)	(69.02-145.0)	(101.8-232.8)	(194.9-442.2)	(348.2-557.8)	(484.4-717.5)	(737.3-748.3)	(820.3-900.2)	
B. bjoerkna	n	32	43	37	82	91	80	59	71	44	8
	ML±SE	11.3±1.23	13.9±0.83	16.4±0.84	18.3±0.76	19.6±0.57	21.1±0.60	22.3±0.53	23.9±0.82	26.1±0.85	28.3±1.14
		(6.2-12.7)	(12.5-15.6)	(15.1-17.6)	(16.7-19.4)	(17.0-20.5)	(18.5-22.5)	(20.2-23.5)	(21.1-25.2)	(22.7-27.4)	(27.1-30.4)
	MW±SE	17.82±5.15	30.58±6.88	54.39±13.68	80.40±10.58	93.86±12.54	115.11±18.35	139.45±21.65	177.85±31.16	236.59±31.70	302.43±46.49
		(3.15-30.49)	(16.71-46.98)	(31.35-85.89)	(53.37-106.1)	(71.45-138.0)	(76.47-168.3)	(87.18-188.1)	(121.3-246.2)	(185.4-317.6)	(198.6-347.4)
C.gibelio	n	45	51	15	30	23	12	3			
	ML±SE	12.7±0.99	15.9±1.64	21.3±0.99	24.3±0.90	26.6±0.78	28.8±0.91	31.8±0.54			
		(9.3-13.7)	(13.7-19.5)	(19.6-22.7)	(22.6-25.9)	(24.9-28.1)	(27.8-30.9)	(31.4-32.4)			
	MW±SE	40.37±8.97	77.10±24.92	191.76±37.34	254.18±49.50	325.37±61.90	425.02±73.72	499.65±80.76			
		(13.76-55.10)	(42.59-137.6)	(130.1-276.5)	(183.1-434.1)	(232.7-463.8)	(298.6-557.6)	(448.5-592.7)			
R.rutilus	n	25	32	28	13	15	12	13	8	6	
	ML±SE	12.4±0.57	15.3±1.35	18.1±1.62	20.6±0.78	22.9±1.23	25.1±1.35	27.2±1.47	29.1±1.26	30.4±1.26	
		(11.2-13.4)	(13.4-17.8)	(14.5-20.3)	(18.8-21.4)	(20.6-24.0)	(23.2-26.9)	(24.8-29.6)	(27.6-30.9)	(28.7-32.2)	
	MW±SE	22.79±3.53	34.34±10.94	62.76±20.22	105.89±27.48	128.03±20.55	166.25±44.87	218.58±55.49	295.58±87.46	382.39±73.87	
		(14.46-30.28)	(23.44-64.25)	(26.25-96.67)	(60.53-158.9)	(92.02-179.0)	(108.1-248.8)	(122.6-305.4)	(167.7-449.6)	(282.1-496.5)	
V.vimba	n	3	68	37	20	72	46	18			
	ML±SE	13.0±0.59	14.7±1.04	18.8±1.31	21.1±0.89	22.6±1.02	24.8±0.68	26.8±0.89			
		(12.3-13.4)	(12.7-16.8)	(15.6-20.9)	(19.2-23.3)	(20.6-24.3)	(23.1-26.5)	(25.8-29.1)			
	MW±SE	26.20±4.66	31.95±8.97	79.95±24.35	116.74±14.12	132.86±16.81	156.84±22.19	209.07±41.89			
		(20.86-29.46)	(20.79-63.63)	(32.5-135.48)	(78.19-141.9)	(93.4-182.34)	(111.8-238.2)	(172.3-322.6)			

Table 2. Growth parameters (L_{∞}, k, t_0) and growth performance index (Ø') for five fish species.

Species	N	L_{∞}	k	t_0	Ø'
Abramis brama	141	92.18	0.054	-0.040	2.628
Blicca bjoerkna	547	69.40	0.04	-0.030	2.268
Carassius gibelio	179	51.09	0.114	-0.024	2.474
Rutilus rutilus	152	48.11	0.088	-0.023	2.307
Vimba vimba	264	41.74	0.104	-0.035	2.260

Table 3. Growth parameters (L_{∞}, k, t_0) and growth performance index (Ø') for five fish species studied by different authors.

Species	Location	N	L_{∞}	k	t_0	ø'	References
Abramis brama	Dąbie Lake	290	44.62***(TL)	0.175	0.23	2.542	Kompowski, 1988
	Volvi Lake	443	50.7*(FL)	0.094	-0.41	2.383	Valoukas & Economidis, 1996
	Rubikiai Lake	209	65.7***(SL)	0.085	0.482	2.565	Žiliukienė & Žiliukas, 2011
	Sakarya River	141	92.18***(TL)	0.054	-0.01	2.628	This study
Blicca bjoerkna	Berounka River		23.4***(SL)	0.270	-0.27	2.169	Hanel, 1991
	Balaton Lake	127	35.9***(SL)	0.098	-0.639	2.101	Specziár et al., 1997
	Sapanca Lake	350	31.91*(TL)	0.122	-1.087	2.10	Okgerman et al., 2012
	Ladik Lake	434	32.85***(FL)	0.11	-2.64	2.074	Yilmaz et al., 2015
	Sakarya River	547	69.4***(TL)	0.04	-0.02	2.268	This study
Carassius gibelio	Lysimachia Lake		32.5***(FL)	0.282	-0.51	2.47	Leonardos et al., 2001
	Egirdir Lake	616	33.3***(FL)	0.346	-0.302	2.58	Balık et al., 2004
	Aksu River	128	36.86***(TL)	0.244	-0.791		İnnal, 2012
	Seyhan River	317	32.30***(TL)	0.307	-0.526	2.505	Ergüden, 2015
	Sakarya River	177	51.09***(TL)	0.11	-0.02	2.458	This study
Rutilus rutilus	Volvi Lake	233	33.3***(TL)	0.081	-1.30	1.95	Papageorgiou, 1979
	Berounka River		28.5***(SL)	0.169	-0.17	2.14	Hanel, 1991
	Balaton Lake	112	31.9***(SL)	0.160	0.026	2.21	Specziár et al., 1997
	Sapanca Lake	136	31.87**(TL)	0.195	-0.034	2.297	Okgerman et al., 2009
	Sakarya River	152	48.11***(TL)	0.09	-0.02	2.318	This study
Vimba vimba	Berounka River		27.8***(SL)	0.212	-0.22	2.214	Hanel, 1991
	Caspian Sea coast	845	26.1***(FL)	0.280	-0.65	2.280	Chaichi et al., 2011
	Sapanca Lake	217	24.70*(FL)	0.205	-1.464	2.097	Okgerman et al., 2011
	Sakarya River	264	41.74***(TL)	0.10	-0.04	2.241	This study

*Female, **Male, ***Combined

(Table 4). These differences may be due to the sampling method, fishing activity, feeding habitats, population density and the ecological condititions of water bodies.

The ages and lengths of the *R. rutilus* ranged between 1^+ - 9^+ years, 11.2 to 32.2 cm in the lower Sakarya River (Table 1). In other research on *R. rutilus*, age distribution was reported to be 1^+ - 6^+ (Sedaghat & Hoseini, 2012) in the Southern Caspian Sea, 1^+ - 4^+ in Seyhan Dam Lake (Ergüden, Ergüden, & Göksu, 2008). Due to the maximum size obtained in the sampling, asymptotic length value calculated for *R. rutilus* was found higher compared to the research in Table 3.

Despite wide distribution of *V. vimba* individuals, information on the biology of this species in Turkey is scarce. The age composition of this species was between 1^+ - 7^+ in the present study. The growth rate for length and weight in this research was generally high in comparison with populations from other studies (Table 4). The growth performance index of *V. vimba* (ø') in the lower Sakarya River was similar to that previously reported, apart from 2.097 (ø') *V. Vimba* caught in the Sapanca Lake (Okgerman, Elp, & Yardımcı, 2011). The differences in the growth of Vimba between regions might have been because of the ecological condititions of the Sakarya River, competition for food between Vimba and the other fish species and differences on condition, length, age, sex, and gonadal development of *V. vimba* (Ricker, 1975).

Growth can be evaluate when age and size information are combined. Growth provides us with some indication of resource utilization and the effectiveness of our management strategies.

Table 4. Mean length and mean weight for different age groups of five fish species studied by different authors.

Species	Location	Sex		Age										References
				1+	2+	3+	4+	5+	6+	7+	8+	9+	10+	
Abramis brama	Solina dam reservoir	Combined	TL				25.9	30.8	33.5	34.0	35.2	36.9	38.1	Epler et al., 2006
			W				214	364	457	457	496	548	598	
	Rubikiai Lake	Combined	SL	5.6	10.0	13.6	17.0	21.5	24.3	27.6	30.2	33.2	35.9	Žiliukienė & Žiliukas, 2011
			W	3	18	50	97	196	296	403	578	767	957	
	Ladik Lake	Combined	FL	12.72	16.14	18.08	23.9	28.75	34.09	39.53	42.16			Yılmaz et al., 2015
			W	32.41	65.14	95.54	258.3	418.6	749.2	1167	1435.2			
	Sakarya River	Combined	TL		18.3	21.2	24.6	30.0	33.1	36.1	39.1	41.4		This study
			W		66.92	104.64	167.60	299.39	416.40	560.22	762.81	872.23		
Bilicca bjoerkna	Balaton Lake	Combined	SL	8.4	10.9	13.0	15.0	16.8	18.8	20.5	22.0			Specziár et al., 1997
			W	12.0	28.4	50.9	79.9	117	166	220	274			
	Sapanca Lake	Female	TL	6.9		12.99	14.96	16.73	17.80	20.01	20.77	23.2		Okgerman et al., 2012
			W	3.35		23.32	39.23	58.28	70.02	109.73	110.0	159.4		
	Uluabat Lake	Combined	FL	8.35	10.55	12.34	13.80	15.32	16.31	17.85				Şaşı & Berber, 2012
			W	9.56	13.73	31.02	80.17	90.32	104.93	122.68				
	Aras Dam Lake	Female	TL	17.07	20.14	21.18	23.49	23.65						Jamali et al., 2015
			W	58.7	112.2	126.1	157.9	161.7						
	Sakarya River	Combined	TL	11.3	13.9	16.4	18.3	19.6	21.1	22.3	23.9	26.1	28.3	This study
			W	17.82	30.58	54.39	80.40	93.86	115.11	139.45	177.85	236.59	302.43	
Carassius gibelio	Egirdir Lake	Combined	FL	11.9	18.1	22.9	25.5	27.4	29.6					Balık et al., 2004
			W	42.0	145.2	297.0	451.4	602.1	857.5					
	Aksu River	Combined	TL	12.16	17.91	21.19	24.18	26.93	29.43					İnnal, 2012
			W	40.71	109.41	179.43	285.38	452.21	540.3					
	Seyitler Reservoir	Combined	FL	15.35	17.74	21.02	23.79	25.56		31.75				Bulut et al., 2013
			W	46.15	130.6	214.11	300.38	348.46		755.4				
	Rozov Klade-nets Reservoir	Combined	SL	11.64	15.78	17.86	19.78	21.48	23.91					Zhelev et al., 2015
			W	42.82	90.79	118.24	160.55	198.26	263.40					
	Sakarya River	Combined	TL	12.7	15.9	21.3	24.3	26.6	28.8	31.8				This study
			W	40.37	77.10	191.76	254.18	325.37	425.02	499.65				

Table 4. Continue.

Species	Location	Sex		Age										References
				1+	2+	3+	4+	5+	6+	7+	8+	9+	10+	
Rutilus rutilus	Volvi Lake	Combined	TL	7.6	11.3	12.3	13.9	15.1	16.0	17.2	18.1	19.3	20.5	Papageorgiou, 1979
			W	2.93	13.59	19.30	24.86	39.98	48.74	63.85	71.92	77.24	101.35	
	Solina Reservoir	Combined	TL			15.8	19.9	21.3	22.3	23.5	25.0			Epler et al., 2005
			W			47.3	101.2	125.7	152.5	201.5	210.0			
	Seyhan Dam Lake	Combined	FL	14.72	17.40	19.25	22.04							Ergüden et al., 2008
			W	47.23	75.12	94.50	185.62							
	Sapanca Lake	Female	TL	7.25	12.79	16.26	18.67	20.10	21.66	24.13	28.58	30.97		Okgerman et al., 2009
			W	5.19	25.38	47.56	81.14	99.01	122.96	183.59	315.34	412.53		
	Sakarya River	Combined	TL	12.4	15.3	18.1	20.6	22.9	25.1	27.2	29.1	30.4		This study
			W	22.79	34.34	62.76	105.89	128.03	166.25	218.58	295.58	382.39		
Vimba vimba	Sariyar Dam Lake	Combined	FL		10.45	14.61	16.98	19.12	20.97	23.12				Ekmekci & Erk'akan, 1992
			W		13.50	42.02	74.55	112.05	161.07	235				
	Kirmir Stream	Combined	FL	10.62	13.01	15.01	17.78	19.54						Tutucu, 2002
			W	15.64	31.89	51.52	88.70	124.42						
	Barycz River	Female	TL	6.2	12.2	17.9	23.5							Łuszczek-Trojna- ret al., 2008
			W	2.25	17.1	67.6	145.9							
	Sapanca Lake	Female	FL		12.62	14.58	17.03	17.87	19.43					Okgerman et al., 2011
			W		27.47	46.49	71.38	82.75	103.58					
	Sakarya River	Combined	TL	13.0	14.7	18.8	21.1	22.4	24.8	26.8				This study
			W	26.20	31.95	79.95	116.74	132.86	156.84	209.07				

When we evaluate age and growth in combination, the relationship between population size and biomass can be easier to understand. This understanding is the basis of modern fisheries resource allocation and management.

CONCLUSION

In conclusion, this study provides basic information on age and growth of *A. brama, B. bjoerkna, C. gibelio, R. rutilus* and *V. vimba* living in the lower Sakarya River. The results of this study are useful for evaluating the relative condition of fishery managements and stock assessment in the Sakarya River. Also, this study will contribute to further scientific studies in the same area.

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