

Age and Growth Parameters of the Antalya Bleak *Alburnus baliki* Bogutskaya, Küçük & Ünlü, 2000 (Actinopterygii: Cyprinidae) in the Manavgat River Estuary, Turkey

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Abstract: The present study reports the age and growth parameters of the Antalya bleak *Alburnus baliki* from the estuary of the Manavgat River, Antalya, Turkey. We collected 234 specimens of *A. baliki*, which ranged between 1.7 and 15.9 cm in total length and between 0.028 and 44 g in total weight. Of these, 41 were immature, 80 were female and 113 were male. The scales indicated the presence of five age classes (0-IV). Length-weight relationships were fitted using the equation $W=0.0033L^{3.4456}$ ($R^2=0.99$) for females and $W=0.0033L^{3.4538}$ ($R^2=0.99$) for males and $W=0.0046L^{3.2895}$ ($R^2=0.99$) for both sexes combined, thus indicating a positive allometric growth. The mean value of the condition factor was calculated as 0.77 and ranged from 0.52 to 1.20. This study provided the first baseline data related to length-weight relationship, age, sex ratio and condition factor for *A. baliki*. Its populations are threatened due to various ecological changes in its habitats, leading to increased concern and the need for conservation.

Key words: *Alburnus baliki*, age, growth, condition factor, Manavgat River

Introduction

River ecosystems of Turkey are recognised as areas with significant number of endemic taxa, many of which are also considered rare (KÜÇÜK et al. 2007, ERK'AKAN & ÖZDEMİR 2011, GÜÇLÜ et al. 2013). The high prevalence of endemic species is explained by the persistence of important geographic barriers. A total of 27 species of *Alburnus* (family Cyprinidae) have been recorded in freshwater systems of Turkey (MANGIT & YERLİ 2018). Most of these species are endemic (FISHBASE 2018). One endemic lotic species of this genus is *Alburnus baliki* Bogutskaya, Küçük & Ünlü, 2000 (Fig. 1). It is commonly known as the "Antalya bleak". *Alburnus baliki* is only known from the Manavgat River Basin. It forms schools along the banks just under the water surface in clean, slow-flowing waters with very dense aquatic vegetation (BOGUTSKAYA et al. 2000). The conservation status

of the fish species is "endangered" (FREYHOF 2014).

The Manavgat River originates in the Taurus Mountains at about 2100 m and drains to the Mediterranean, entering it in the Antalya Bay. The Oymapınar and Manavgat Dams were constructed on this river (BOGUTSKAYA et al. 2000). Küçük & İkiz (2004) studied fish species of the Manavgat River. It has been affected by large-scale anthropogenic influences, mainly the substantial development of tourism activities and the increasing population in the catchment (D. Innal, pers. observation). Estuaries are naturally highly dynamic and rapidly changing systems, forming a complex mixture of many different habitat types (MEIRE et al. 2005). Estuaries are becoming contaminated by various anthropogenic activities due to a quick economic growth and urbanisation (KHAN et al. 2014). Information about the

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fish composition in estuaries in Turkey is rare, with the exception of studies in the Köyceğiz Lagoon Estuary (AKIN et al. 2005), Göksu River Estuary (KÜÇÜK et al. 2007), Gediz Estuary (BAYHAN et al. 2008; KARA et al. 2018), Kundu Creek Estuary (İNNAL & ÖZDEMİR 2012), Köprüçay River Estuary (İNNAL 2012), Aksu River Estuary (İNNAL 2016).

Data on the biology of *A. baliki* are limited despite its ecological importance. BOGUTSKAYA et al. (2000) described it as a new species and performed its morphometric characterisation. MANGIT & YERLİ (2018) studied the taxonomy of the genus. AYDOĞDU et al. (2011) reported infections of the parasite *Pomphorhynchus laevis* (Müller, 1776) (Acanthocephala) from Antalya bleak.

Despite its ecological importance, the growth of *A. baliki* has never been studied in the past. The present paper is the first study on age and growth characteristics of *A. baliki* from the Manavgat River Estuary.

Materials and Methods

The Manavgat River Basin is located in southern Turkey (Fig. 2). The river has its source in the Taurus Mts. Two dams (Oymapınar and Manavgat) were constructed on the river for electricity. Fish samples were caught seasonally, between November 2014 and June 2017, with shore seine net and nets of various mesh sizes. All fish were collected from the river mouth area (36°43'21.87 N 31°29'24.68 E) at water depths ranging 40–600 cm. After being caught, the fish samples were transported to the laboratory where their size (total length in cm, referred to as L in the text) and weight (in g, referred to as W in the text) were measured and weighed to the nearest 1.0 mm and 0.1 g, respectively. Length frequency distributions were compared using the Kolmogorov–Smirnov two-sample tests. The sex of the specimens was identified based on the macroscopic analysis of the gonads. Differences in the sex ratio were estimated with a t-test ($p > 0.05$). The scales of individuals were used for age determination. The Roman numerals indicate a subjective classification of ages. Previous studies confirm the successful use of scales to validate age in the closely related species of *Alburnus* (YILMAZ & SUIÇMEZ 2010, ALKAN UÇKUN & GÖKÇE 2015). The length-weight relationship was calculated using the equation $W = aL^b$ (FROESE 2006), where a was a coefficient related to body form and b was an exponent indicating isometric growth when equal to 3. The positive or negative allometric growth occurred when the b value deviated significantly from 3. The significance of the b value for all popu-



Fig. 1. *Alburnus baliki* from the Manavgat River.

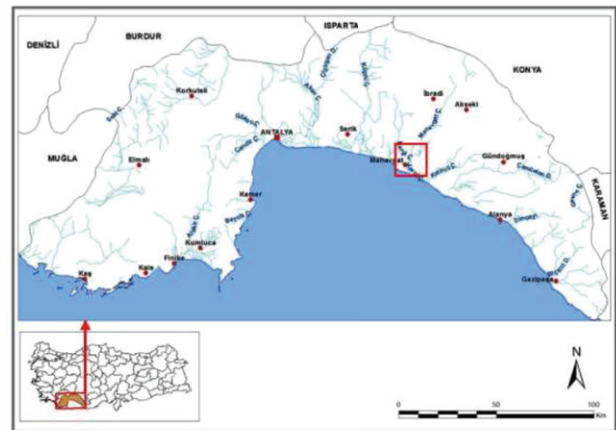


Fig. 2. Map of Turkey showing the location of the Manavgat River.

lations was tested with a t-test ($p > 0.05$). Condition coefficients were calculated for both sexes using the equation $K = (W/L^3) \times 100$ (FROESE 2006), where K was the condition factor, W was the weight of the fish (g) and L was the total length (cm). Differences in the condition factors were estimated using a one-way ANOVA followed by Tukey multiple-range test.

Results

Based on the age determination of *A. baliki*, we recorded 113 (48.3%) males, 80 (34.2%) females and 41 (17.5%) juveniles (Table 1). The male–female ratio for all fish combined was 1.41:1 and differed statistically from the expected 1:1 ($P < 0.05$). The ages of the captured specimens ranged from 0 to IV years and the first group was dominant in the population, followed by age II (26.5%), 0 (14.5%), III (9.4%) and IV (0.9%) age groups (Table 2).

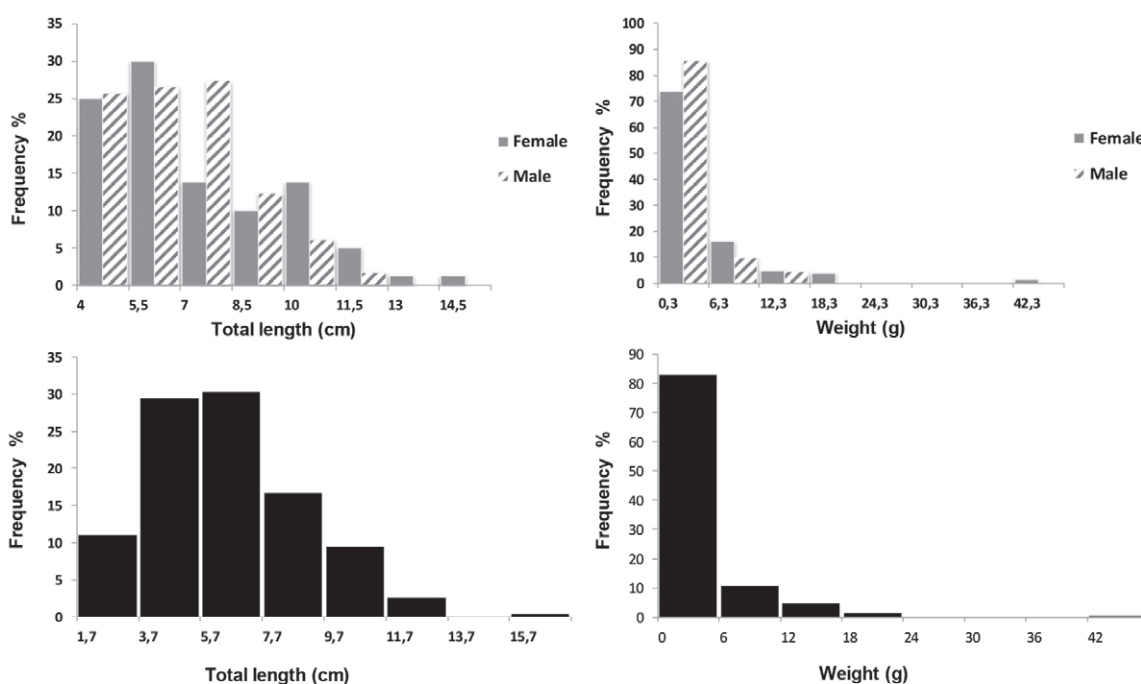
Specimens of *A. baliki* ranged from 1.7 to 15.9 cm in total length and from 0.028 to 44 g in total weight. Total length ranged from 4 to 12.1 cm in males, from 4 to 15.9 cm in females and from 1.7 to 5.5 cm in juveniles. Weight ranged from 0.37 to

Table 1. Sex and age compositions of *Alburnus baliki* in the Manavgat River Estuary

Age	Female		Male		Juvenile		All individuals	
	N	%	N	%			N	%
0		0.0		0.0	34	14.5	34	14.5
I	45	19.2	62	26.5	7	3.0	114	48.7
II	20	8.5	42	17.9		0.0	62	26.5
III	13	5.6	9	3.8		0.0	22	9.4
IV	2	0.9		0.0		0.0	2	0.9
Total	80	34.2	113	48.3	41	17.5	234	100.0

Table 2. Length-frequency distribution of *Alburnus baliki* in the Manavgat River Estuary

Length intervals (cm)	Age groups (in years)					
	0	I	II	III	IV	Total
1.0-2.99	15					15
3.0-4.99	19	46				65
5.0-6.99		64				64
7.0-8.99		4	52			56
9.0-10.99			10	10		20
11.0-12.99				12		12
13.0-14.99					1	1
15.0-16.99					1	1
Total	34	114	62	22	2	234
TL±SD	3.02±0.71	5.50±0.99	8.22±0.84	11.02±0.75	14.7±1.70	6.46±2.52
(min-max)	(1.7-4.0)	(4.0-7.1)	(7.1-10.2)	(10.1-12.5)	(13.5-15.9)	(1.7-15.9)
W±SD	0.21±0.12	1.35±0.77	4.93±1.95	13.8±3.37	33.21±15.25	3.58±5.03
(min-max)	(0.028-0.46)	(0.37-2.82)	(2.75-10.53)	(10.44-23.16)	(22.43-44)	(0.028-44)


Fig. 3. Length and weight distribution of *Alburnus baliki* in the Manavgat River Estuary.

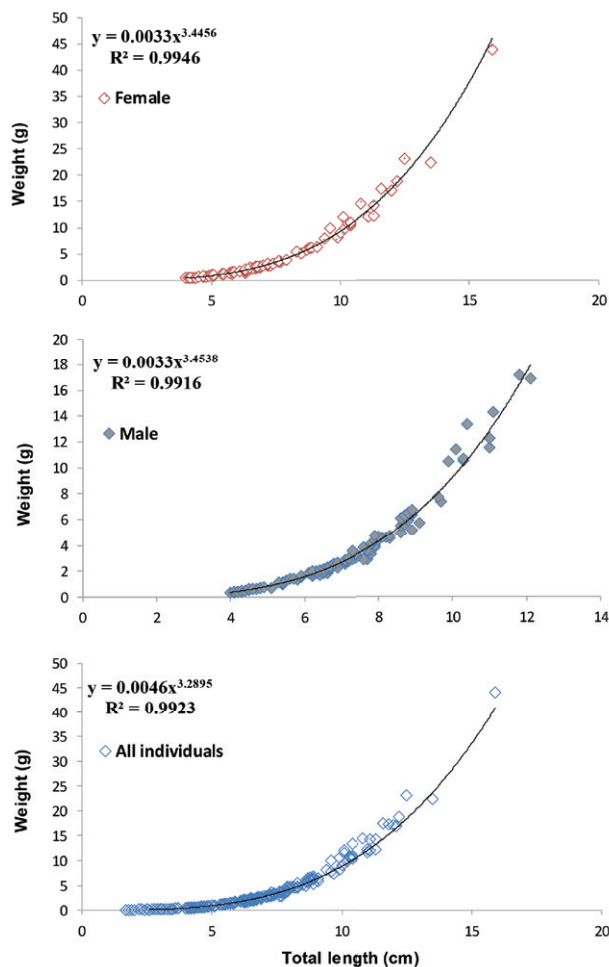


Fig. 4. Length-weight relationships for *Alburnus baliki* from the Manavgat River Estuary.

17.26 g in males, from 0.4 to 44 g in females and from 0.028 to 1.25 g in juveniles. The mean total length and weight of females were higher than males. No significant difference was observed in mean length and weight between sexes ($P > 0.05$).

Among all individuals, most fish had total length of 4-5.5 cm and weight ranged 0.3-6.3 g (Fig. 3). The length frequency distributions of males and females were not significantly different (Kolmogorov-Smirnov two-sample test, $p=0.24$).

Length-weight relationships (Fig. 4) were calculated by using the data of 234 *A. baliki* specimens. These were found to be $W=0.0033L^{3.4456}$ ($R^2=0.99$) for females, $W=0.0033L^{3.4538}$ ($R^2=0.99$) for males and $W=0.0046L^{3.2895}$ ($R^2=0.99$) for all individuals. The exponent $b > 3$ indicated a positive allometric growth characteristic.

The mean condition factor (Fig. 5) of the all individuals was 0.77 and ranged from 0.52 to 1.20. The condition factor was greater than 1 at size range 12.0-15.9 cm. Differences in mean condition factors of males and females from the estuary of the

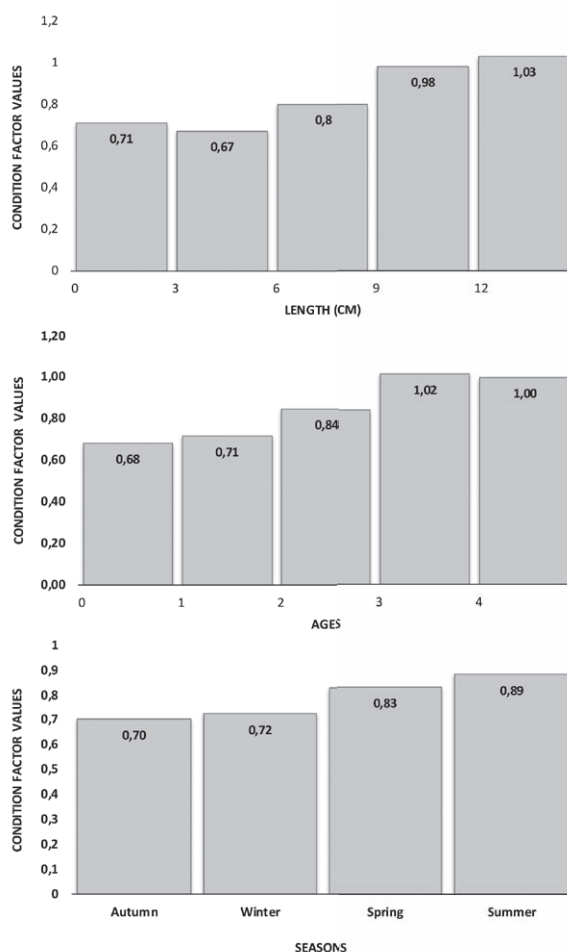


Fig. 5. Mean condition values of *Alburnus baliki* in the Manavgat River Estuary

Manavgat River were not statistically significant. The highest value occurred in summer (0.89) and the lowest value in autumn (0.70). Seasonal differences in mean condition factors were statistically significant (ANOVA, $F=14.55$, $P<0.001$).

Discussion

Although more than 100 endemic species exist in Turkey, little is known about their life history. The biology of *A. baliki* has been reported in terms of morphology and taxonomy (BOGUTSKAYA et al. 2000, MANGIT & YERLI 2018) as well as parasitology (AYDOĞDU et al. 2011). This work is the first study on age and growth for the Antalya bleak in Turkey, thus no comparisons are possible with previous studies in the region.

Alburnus baliki is one of the abundant fish species in the Manavgat River Estuary. Except for *Alburnus tarichi*, the other species of the genus *Alburnus* have no commercial value. Statistics on the catches of this species are unfortunately not availa-

Table 3. Length-weight relationships of species of the genus *Alburnus* from Turkey.

Reported species	Locality	n	Type	L _{MIN}	L _{MAX}	a	b	R ²	References
<i>A. mossulensis</i>	Karakaya Reservoir	626	FL	10.8	19	0.135	2.12	0.94	ALKAN UÇKUN & GÖKÇE (2015)
<i>A. tarichi</i>	Lake Van	240	FL	14.3	19.2	0.074	2.544	0.84	BOSTANCI & POLAT (2011)
<i>A. heckeli</i>	Lake Hazar	260	TL	8.98	12.4		2.547	0.73	BAL & Çalta (2012)
<i>A. orontis</i>	Asi River	31	TL	5.7	9.8	0.001	2.555	0.838	Özcan & ALTUN (2015)
<i>A. mossulensis</i>	Kalecik Reservoir	158	TL	12	18	0.0218	2.619	0.681	KARAMAN et al. (2014)
<i>A. adanensis</i>	Seyhan Reservoir	151	TL	13.8	22	0.031	2.63	0.926	ERGÜDEN & GÖKSU (2009)
<i>A. esherichii</i>	Pelitözü Pond	50	TL	2.7	9.3	0.0086	2.9469	0.971	ÇETINKAYA et al. (2015)
<i>A. chalcoides</i>	Çakırköy Brook	190	FL	6.1	16	0.0118	2.9964	0.99	BAŞDEMİR et al. (2010)
<i>A. esherichii</i>	Karasu Creek	18	TL	9.4	16	0.008	3.0893	0.956	ÇETINKAYA et al. (2015)
<i>A. esherichii</i>	Ertuğrulgazi Pond	50	TL	3	10.4	0.0069	3.1011	0.995	ÇETINKAYA et al. (2015)
<i>A. esherichii</i>	Kızıldamlar Reservoir	50	TL	2.8	15.9	0.0065	3.1333	0.996	ÇETINKAYA et al. (2015)
<i>A. esherichii</i>	Dodurga Reservoir	18	TL	15.2	19.8	0.0075	3.1879	0.85	ÇETINKAYA et al. (2015)
<i>A. esherichii</i>	Küçükemalı Pond	25	TL	3.5	16.4	0.0058	3.2425	0.998	ÇETINKAYA et al. (2015)
<i>A. esherichii</i>	Çamkoru Pond	308	FL	7.5	16.4	0.0066	3.2501		İnnal (2010)
<i>A. esherichii</i>	Kurtköy Pond	52	TL	3	16.6	0.0049	3.2548	0.996	ÇETINKAYA et al. (2015)
<i>A. baliki</i>	Manavgat River Estuary	234	TL	1.7	15.9	0.0046	3.2895	0.99	Present study
<i>A. chalcoides</i>	Almus Reservoir	172	TL	10.8	18.8	0.0019	3.577	0.94	YILMAZ & SUIÇMEZ (2010)

ble. The Antalya bleak has been listed as endangered as a result of habitat loss, flow alterations, dam constructions and pollution (FREYHOF 2014). During a three-year study in the Manavgat River Estuary, ten alien species including *Carassius gibelio*, *Gambusia holbrooki*, *Liza carinata*, *Oncorhynchus mykiss*, *Pseudorasbora parva*, *Siganus rivulatus*, *Sillago suezensis*, *Sphyræna chrysotaenia*, *Upeneus moluccensis* and *Upeneus pori* were caught. Increasing populations of alien species may threaten the population of *A. baliki*.

In this study, we caught more male individuals than females. This is in agreement with data reported for *A. chalcoides* in the Çakırköy Creek (BAŞDEMİR et al. 2010). On the contrary, female dominance was reported for *A. chalcoides* in the Almus Reservoir (YILMAZ & SUIÇMEZ 2010) and for *A. mossulensis* in the Karakaya Reservoir (ALKAN UÇKUN & GÖKÇE 2015). The occurrence of sexual differences in life span is well documented in cyprinids of Turkey (TARKAN et al. 2005, İNNAL 2010, OYMAK et al. 2011). Males of *A. baliki* were observed with a greater number of in the younger age classes. Older age classes were dominated by females. Reasons for the unequal sex ratio for mature fish may be different and numerous: the seasonal aspect, feeding and maturation periods, habitat selection, mortality difference for each sex and perhaps size-selective ef-

fects of the fishing gear. It is not clear which factors might be responsible for the fluctuation of male and female life span of *A. baliki* in the Manavgat River Estuary.

The age of captured fish ranged between groups 0 and IV. The highest estimated ages were IV years for females and III years for males (Table 1). The fact that 63.25% of the specimens were between ages 0 and I indicated that the population contained mostly young individuals. Fish assemblages in estuaries can include larvae, juveniles and adults of both marine and freshwater species, with migratory or sedentary behaviour (CHICHARO et al. 2006). Estuaries have long been recognised as important habitat for juveniles. The high juvenile density recorded for *A. baliki* in the Manavgat River Estuary suggests that it provides important nursery grounds for this species. The previous data support maximum ages of 3 to 8 years for species of *Alburnus* in Turkey (BAŞDEMİR et al. 2010, İNNAL 2010). In the present study, the maximum age was 4 years. Our findings on maximum age of captured *A. baliki* are consistent with the results of previous studies for the genus (ALKAN UÇKUN & GÖKÇE 2015, KESKIN 2016).

In this study, the maximum total length measured for females and males were 15.9 cm and 12.1 cm, respectively. Different maximum lengths have been reported for bleak populations in Turkey, such

as 22 cm for *A. adanensis* in the Seyhan Reservoir (ERGÜDEN & GÖKSU 2009), 19.8 cm for *A. escherichii* in the Dodurga Reservoir (ÇETINKAYA et al. 2015) and 18 cm for *A. mossulensis* in the Kalecik Reservoir (KARAMAN et al. 2014). These length values indicated that the Anatolian populations of the bleak contain larger specimens than the Manavgat River Estuary populations.

The values of *b* for *A. baliki* were within the limits of 2.5-3.5, commonly reported for teleosts by FROESE (2006). There have been some studies on the length-weight relationships of the genus (ERGÜDEN & GÖKSU, 2009, BAŞDEMİR et al. 2010, Yılmaz & SUIÇMEZ 2010, İNNAL 2010, BOSTANCI & POLAT 2011, BAL & ÇALTA 2012, KARAMAN et al. 2014, ALKAN UÇKUN & GÖKÇE 2015, ÇETINKAYA et al. 2015, ÖZCAN & ALTUN 2015) and the values for *b* reported in these studies are presented in Table 3. The *b* value of *Alburnus* species in Turkey has been shown to range from 2.12 to 3.577. All possible values (i.e. describing isometric, as well as positive or negative allometric relationships) have been reported. Length-weight regressions were very similar in both sexes of *A. baliki*. The slope *b* value of the LWR equations of *A. baliki* was 3.29 indicating a positive allometric growth (FROESE 2006). Similar results were found for the *A. chalcoides* populations in the Almus Reservoir (YILMAZ & SUIÇMEZ 2010), for *A. escherichii* in the Çamkoru Pond (İNNAL 2010), Ertuğrulgazi Kurtköy and Küçükelmali Ponds, Karasu Creek, Dodurga and Kızıldamlar Reservoirs (ÇETINKAYA et al. 2015). Slightly different results have been observed for *A. adanensis* in the Seyhan Reservoir (ERGÜDEN & GÖKSU 2009), for *A. mossulensis* in the Kalecik Reservoir (KARAMAN et al. 2014) and Karakaya Reservoir (ALKAN UÇKUN & GÖKÇE 2015) and for *A. tarichi* in Lake Van (BOSTANCI & POLAT 2011). Length-weight relationships of bleak populations are affected by many ecological and individual factors. Geographic location and associated environmental conditions, such as seasonality (date and time of capture), stomach fullness, disease and parasite loads, can also affect the value of *b* (LE CREN 1951, BAGENAL & TESCH 1978).

Differences of the condition factor values between length, age classes and seasons may be attributed to growth stages, feeding activity and spawning capacity. It was highest in summer for the Antalya bleak in the Manavgat River Estuary and declined throughout the rest of the year. These changes in condition are most likely attributed to intrinsic factors, such as gonad maturity, seasonal availability of diet items, parasitism. Mean condition factor of the all individuals was calculated as 0.77 in this study.

Condition factors of Anatolian bleak populations have been described by several authors (YILMAZ & SUIÇMEZ 2010, ÖZCAN & ALTUN 2015, ALKAN UÇKUN & GÖKÇE 2015) with values varying greatly from one population to another within the same species and species of the same genus. Mean condition factor values were reported as 0.89 for *Alburnus chalcoides* in the Almus Reservoir (YILMAZ & SUIÇMEZ 2010); 0.645 for males and 0.633 for females of *Alburnus heckeli* in the Hazar Reservoir; 0.404 for *Alburnus orontis* in the Asi River (ÖZCAN & ALTUN 2015). The differences in condition factor values are thought to have resulted from the effects of such factors as biology of species, environmental parameters of the studied areas, the period of sampling and size of the samples.

In conclusion, the growth characteristics for *A. baliki* are not much different from those of closely-related congeneric species. This study provides some basic, essential information on *A. baliki* from the Manavgat River Estuary and is thought to be useful for future studies. A detailed study of current population status and biology (parasites, diet, reproduction parameters, genetic structure) is required.

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