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CONDITION, LENGTH-WEIGHT AND LENGTH-LENGTH RELATIONSHIPS FOR FIVE FISH SPECIES FROM HIRFANLI RESERVOIR, TURKEY

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Abstract: The condition (K), length-weight and length-length relationships, total length (TL), fork length (FL), and standard length (SL) were described herein for the following 5 fish species inhabiting Hirfanlı Reservoir (Central Anatolia): *Pseudorasbora parva*, *Atherina boyeri*, *Aphanius danfordii*, *Tinca tinca*, and *Cyprinus carpio*. Fish specimens were obtained between March and November 2008 using trawl nets. The length-weight relationship exponent *b* value ranged from 2.896 in *C. carpio* to 3.67 in *A. danfordii*. The *b* value for all species deviated from 3 and positive allometric growth was observed for *A. danfordii*, *A. boyeri*, *P. parva*, and *T. tinca*. Fulton's condition factor varied between 0.604 (*A. boyeri*) and 1.721 (*A. danfordii*). The length-length relationships were significantly linear.

Keywords: Exotic fish, Endemic fish, Length-weight relations, Condition, Hirfanlı Reservoir

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Öz:

Hirfanlı Baraj Gölü'nde Yaşayan Beş Balık Türünün Kondisyonu, Boy-Ağırlık ve Boy-Boy İlişkileri

Sunulan çalışmada, Hirfanlı Baraj Gölü (İç Anadolu Bölgesi)'nde yaşayan 5 balık türünün – *Pseudorasbora parva*, *Atherina boyeri*, *Aphanius danfordii*, *Tinca tinca*, and *Cyprinus carpio*– kondisyon, boy-ağırlık ve total boy (TL), çatal boy (FL) ve standart boy (SL) arasındaki boy-boy ilişkileri belirlenmiştir. Balık örnekleri Mart ve Kasım 2008 arasında ığrıp ağları kullanılarak yakalanmıştır. Boy-ağırlık ilişkisindeki *b* değeri *C. carpio*'da 2.896 ve *A. danfordii*'de 3.67 arasında değişmektedir. Bütün türlerde *b* değeri 3'ten sapma göstermekte ve *A. danfordii*, *A. boyeri*, *P. parva*, and *T. tinca*'da pozitif allometrik büyüme görülmektedir. Fulton kondisyon faktörü 0.604 (*A. boyeri*) ile 1.721 (*A. danfordii*) arasında değişmektedir. Boy-boy ilişkileri önemli derecede doğrusaldır.

Anahtar Kelimeler: Yabancı balık türleri, Endemik balıklar, Boy-ağırlık ilişkisi, Kondisyon, Hirfanlı Baraj Gölü

Introduction

The length-weight relationship (LWR) is an important tool in fishery management. Primarily, the relationship between fish length and weight can be used to convert length to weight and vice versa. Fish length is often more rapidly and accurately measured than fish weight (Le Cren1951). In particular, length can be measured more easily than weight during field studies; therefore, weight can be estimated after field studies using the length-weight relationship. Furthermore, length-weight regressions have been used extensively for conversion of growth in length equations to growth in weight equations in the stock assessment models; for estimation of standing-crop biomass when the length frequency distribution is known, and for predicting the condition index (Le Cren 1951; Wootton 1990; Petrakis and Stergiou 1995; King, 1996). Additionally, the LWR is useful for comparing the life history of a species in different regions and/or seasons (Wootton, 1990; Gonçalves et al. 1997) and it can be used for morphological comparison of species and populations (Petrakis and Stergiou 1995; King, 1996).

The length-length relationships (LLR) are also important in fishery management. In ichthyological researchs different types of fish length measurements are utilized. For instance, standard length (SL) is used in systematic studies, whereas total length (TL) and fork (FL) length are commonly used for estimation of fish growth. Length measurements of fishes should be standardized to facilitate comparison of different populations; therefore, LLR in different populations should be known. LLR is also important for comparative growth studies (Moutopoulos and Stergiou 2002).

The condition factor is a quantitative parameter of the state of well-being of a fish. Indices of condition are indirect, but sometimes useful indicators of changes in the growth rate (Wootton 1990). The condition of a fish is indicative of recent physical and biological circumstances (Le Cren 1951); thus, the condition factor provides important information about present and future population success via its association with growth, reproduction, and survival.

The aim of the present study was to describe the condition, LWR and LLR for 5 fish species in Hirfanlı Reservoir, Turkey. Of the 5 species presented herein, the endemic species *Aphanius danfordii* has a natural population, whereas *Pseudorasbora parva*, *Atherina boyeri*, *Cyprinus carpio*, and *Tinca tinca* were introduced into the reservoir. LWR of the fish species presently dwelling in Hirfanlı Reservoir was examined in order to understand the effect of the changes in the ichthyofauna due to fish introductions in the reservoir; however, long-term observation is required to observe the effects of changes in the ichthyofauna on fish populations. We hypothesized that findings of the present study would provide a basis for further evaluation of the changes in fish growth following subsequent illegal introduction of alien species into the reservoir.

Materials and Methods

The specimens included in this study were collected from Hirfanlı Reservoir, which is located on the Kızılırmak River Basin in Central Anatolia (33°31′07.16″ E, 39°16′22.2″N). The dam that created the reservoir was completed in

1953. Although the native fish fauna of the reservoir consisted of *Cyprinus carpio*, *Squalius cephalus*, *Capoeta capoeta*, *Silurus glanis*, *Barbus tauricus*, *Alburnus* sp., and *Chondrostoma nasus* at the end of the 1960s, it has changed significantly since then due to anthropogenic effects. Carp, sander, tench, and crayfish (*Astacus leptodactylus*) were introduced into the reservoir after the 1970s for fishery management (Anonymous 2005). Today, such non-native species as *Pseudorasbora parva* and *Atherina boyeri*, and such native endemic species as *Aphanius danfordii* have dense populations in the reservoir and share the same habitat (Ekmekçi et al. 2010).

Samples were caught monthly from March to November 2008 by trawl net with 5-mm mesh from the lakeshore at a maximum depth of 5 m. Fish specimens were anesthetized using MS 222, preserved in 4% formaldehyde solution and then transported to the laboratory for further analysis. TL, FL, and SL were measured to the nearest 0.05 mm, and weight (W) was measured to the nearest 0.001 g. Sex was determined via macroscopic or microscopic observation. The following relationships were established using linear regression analysis; W-TL, FL-TL, SL-TL, and SL-FL. Log-transformed data were used to establish the LWR. The parameters *a* and *b* were calculated using least-squares regression. Both comparison of the slopes of the length-weight regression between sexes and variation in coefficient *b* from 3 were tested using Student's *t*-test (Zar 1999). Fulton's condition factor (K) was calculated using the equation $K = (W/L^3) \times 100$, where W is total body weight (g) and L is total length (cm) (Le Cren 1951).

Results and Discussion

In total, 4598 specimens of 5 fish species belonging to the families Cyprinidae, Cyprinodontidae, and Atherinidae were collected from Hirfanlı Reservoir. The sample size and the relationships between TL, FL, and SL in selected fishes are shown in Table 1. All the examined relationships were significantly linear with all coefficients of determination values ($r^2 > 0.98$, $P < 0.01$).

Length range, LWR parameters *a* and *b*, standard errors of parameters *a* and *b*, and the coefficient of determination (r^2) for selected fishes are given in Table 2. All relationships were statistically significant ($P < 0.01$) and r^2 values were found close to 1. The LWR exponent *b* varied between 2 and 4, but was often a value close to 3 and a value of 3 indicates isometric growth and values other than 3 indicate allometric growth (Tesch, 1971). In the present study, the estimates of the parameter *b* varied between 2.896 for *C. carpio* and 3.67 for A. *danfordii* (Table 2). According to the results, *A. danfordii*, *A. boyeri*, *P. parva*, and *T. tinca* exhibited positive allometric growth ($b > 3$, $P<0.05$), versus negative allometric in *C. carpio* ($b < 3$, $P<0.05$).

The LWR can be indicative of spatial and temporal variations related to water temperature, food availability, and reproductive activity (Wootton 1990). LWR parameters *a* and *b* are affected by a number of factors, including sex, gonad maturity, health status, season, habitat, nutrition, environmental conditions such as temperature and salinity, stomach fullness, general fish condition, differences in length range of fish specimens, and collection gear (Froese 2006; Tesch 1971). In Hirfanlı Reservoir a slight temporal change was observed in the *b* value in *T. tinca* and *C. carpio* (Table 3); however, there was not a difference in the allometric growth pattern between the 2 populations.

Table 2 also shows Fulton's condition factor (K) for selected species. K ranged from 0.604 for *A. boyeri* to 1.721 for *A. danfordii*. Population dynamics studies have shown that high condition factor values indicate favorable environmental conditions (such as habitat and prey availability) and that low values indicate less than favorable environmental conditions (Blackwell et al. 2000). The condition factor fluctuates due to interaction between feeding conditions, parasitic infections, and physiological factors (Le Cren 1951). The condition factor for *C. carpio* and *T. tinca* have a tendency of temporal decrease (Table 3). Differences in the condition factor have been considered indicative of various biological features, such as fatness or suitability of the environment (Le Cren, 1951). The temporal decrease in *K* in both of the species in the present study could be considered indicative of degradation in feeding conditions. On the other hand, a decrease in exponent *b* and K values in *T. tinca* are indicative of possible competition between *C. carpio* and other non-native species recently introduced into the reservoir.

Table 1. Relationships between total, fork and standard length for five fish species in Hirfanlı Reservoir. TL: Total length in mm, FL: Fork length in mm, SL: Standard length in mm, *n:* sample size, *a* and *b* are the parameters of linear regression analysis

Species	*n*	FL = *a* + *b*TL	SL = *a* + *b*TL	SL = *a* + *b*FL
Aphanius danfordii	758	Caudal is not forked	$SL = 0.8416\ TL - 0.1544$	
Atherina boyeri	323	$FL = 0.9375\ TL - 1.0596$	$SL = 0.8623\ TL - 0.3879$	$SL = 0.9168\ FL + 0.7006$
Cyprinus carpio	77	$FL = 0.9184\ TL - 3.5872$		
Pseudorasbora parva	3368	$FL = 0.9211\ TL - 0.672$	$SL = 0.8351\ TL - 1.1086$	$SL = 0.9052\ FL + 0.4474$
Tinca tinca	79	$FL = 0.9727\ TL - 1.0634$		

Table 2. Estimated parameters of the total length-weight relationship and Fulton's condition factor for five fish species shared same habitat in Hirfanlı Reservoir

Species	Length characteristics*		Parameters of the LWR					t value (difference of *b* from 3)	Fulton's condition factor (*K*)	
	min	max	*a*	SE (*a*)	*b*	SE (*b*)	r^2		*K*	SE
Aphanius danfordii	14.70	66.85	-2.1538	0.017	3.668	0.029	0.95	23.0**	1.721	0.466
Atherina boyeri	40.98	110.25	-2.4023	0.027	3.2376	0.034	0.97	7.09**	0.621	0.087
Cyprinus carpio	115	780	-1.6612	0.074	2.8960	0.051	0.98	-3.29**	1.553	0.286
Pseudorasbora parva	18.02	96.24	-2.2432	0.006	3.3237	0.008	0.98	40.46**	0.962	0.198
Tinca tinca	138	339	-1.9368	0.05	3.1016	0.038	0.99	2.67**	1.579	0.107

*TL in mm

** Exponent *b* differed significantly from 3

Table 3. *b* values in LWR and *K* of *C. carpio* and *T. tinca* from Hirfanlı Reservoir during different periods

Species	Source	Period	*b* value	K
C. carpio	Karabatak (1977)	1974-1975	2.531	1.663-1.769
	Yılmaz et al. (2007)	1996-1998	2.59	1.708
	Yılmaz et al. (2010)	2004-2005	2.967	1.973
	Present study	2008-2009	2.896	1.553
T. tinca	Yılmaz et al. (2010)	2004-2005	3.152	1.647
	Present study	2008-2009	3.1016	1.579

Conclusion

In conclusion, the results provide basic information on the LWR, LLR, and condition of 5 introduced and native fish populations in Hirfanlı Reservoir. The temporal changes observed in *b* and K values in the *C. carpio* and *T. tinca* populations, which existed in the reservoir prior to the introduction of *P. parva* and *A. boyeri*, could be considered an indicator of niche competition between the species. We think long-term monitoring is essential to more clearly determine the effects of recently introduced species on the other species that share the same reservoir habitat, and that such findings would be useful for sustainable fishery management in Hirfanlı Reservoir.

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