Length-Weight Relationship of Brown Trout, *Salmo trutta* L., Inhabiting Kan Stream, Çoruh Basin, North-Eastern Turkey

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Abstract

Length-weight and length-length, fork (FL), standard (SL) and total (TL) lengths, relationships were derived for brown trout, *Salmo trutta* L., inhabiting Kan Stream, Çoruh Basin, eastern Turkey. Sampling was done between January–December of 2001 using electronic fishing gear. The relationships between lengths were all significantly linear ($p<0.01$), the *b* value in the length-weight relationship for males and females did not deviate from 3, and this value was significantly lower than 3 in the winter ($p<0.01$), when the temporal changes were taken into account, indicating that only the sampling time affected the growth pattern of *Salmo trutta*. Growth was isometric in the spring, summer and fall, but it was negative and allometric in the winter.

Key Words: length-weight relationship, brown trout, *Salmo trutta*, north-eastern Turkey

Introduction

Total (TL) and fork (FL) lengths are usually utilised in studies of fish growth, whereas standard length (SL) is mainly used in systematic studies. When making comparisons between populations, it is essential to use standard measures for all populations so that the results will be more reliable. This is why the length-length relationship of species under various environmental conditions should be known. Length-length relationship is also important for comparative growth studies (Moutopoulos and Stergiou, 2002). The length-weight relationship is a very useful tool in fisheries assessment. It is usually easier to measure length than weight, and weight be predicted later on using the length-weight relationship. Furthermore, standing crop biomass can be estimated (Morey *et al*., 2003) and seasonal variations in fish growth can be tracked in this way (Ritcher *et al*., 2000).

The length-weight relationship also helps in predicting the condition, reproductive history, and life history of fish species (Nikolsky, 1963; Wootton, 1992; Pauly, 1993; Erkoyuncu, 1995; Avşar, 1998), and in morphological comparison of species and populations (King, 1996; Gonçalves *et al*., 1997).

The early studies on *Salmo trutta* inhabiting Turkish waters were mainly on growth, reproduction and systematic features (Slastanenko, 1955; Aras, 1974; Kuru, 1975; Yıldırım, 1991; Yüksel, 1997; Karataş, 1997; Karataş, 1999; Arslan *et al*., 2000; Tabak *et al*., 2001; Arslan, 2003). Although the estimation of the length-weight relationship was common in these studies, they presented no evidence about the length-length relationship.

We sought to investigate whether temporal changes and sex differences affected the growth of *Salmo trutta* by estimating the length-weight relationship of this species according to sex and sampling time. We also sought to determine the length-length relationship of this species.

Material and Methods

This study was carried out in Kan Stream (44°21" E, 41°12" N), an important tributary of Çoruh River in north-eastern Turkey. It originates on Mount Ovit, and has an elevation of 1,200–2,600 m above sea level. The mean width of brook is 3 m, its mean flow is 3 m^3s^{-1}, and its temperature varies between 1–20°C throughout the year. Although brown trout is the only species of fish regularly found in the brook, some Cyprinids such as *Capoeta tinca* and *Barbus plebejus* occur, infrequently, in its lower reaches. The highway of Erzurum-İspir-Rize runs along the brook and provides easy access to the brook at any point along it. Thus, *Salmo trutta* inhabiting this brook are exploited intensively by amateur fishermen.

Fish samples were collected monthly by means of ENDRESS ES 650 electric fishing gear (220 V AC, 12 V DC) between January and December of 2001. Sampled fish were measured to the nearest 1 mm (TL, FL and SL), and weighted to the nearest 1 g. The relationships between total, fork and standard lengths were determined according to the linear regression model. The length-weight relationship, $W=aFL^b$, was transformed into its logarithmic expression: $\log W=\log(a)+b*\log(FL)$. The parameters *a* and *b* were calculated by least-squares regression for males and females seasonally (spring, summer, fall and winter). Weight-length relationships' curves were compared between both sexes and all four seasons, and the variation in *b* values from 3 were

tested by the *t*-test for evaluating growth curve.

When the *b* value in length-weight relationship was equal to or did not show statistically significant deviation from 3, the growth was isometric, whereas the positive or negative allometric growth occurred when the *b* value deviated significantly from 3 (Ricker, 1975; Erkoyuncu, 1995).

Results

The results of the relationships between total, fork and standard lengths were determined by using the length measures of 511 brown trout samples (Table 1). All relationships were significantly linear ($p<0.01$, $r>0.99$).

The length–weight relationship was determined for sexes and seasons separately, and *b* values varied between 2.89 and 3.04. These values were calculated for males, females and overall as 2.96, 2.96 and 2.97, respectively, and for spring, summer, fall and winter as 3.01, 3.04, 2.91 and 2.89 respectively. The variations in *b* values from 3 were not statistically significant and indicated an isometric growth for males, females, and the overall population when the seasons' effects were not taken into account (Table 2). The variations in *b* values from 3 were not statistically significant in the spring, summer, or fall, but were in the winter ($p<0.01$), implying that while the growth of *Salmo trutta was* negatively allometric during the winter; it was isometric during the rest of the year.

Discussion

Length-weight (according to sexes and sampling time) and length-length (overall) relationships of *Salmo trutta* inhabiting Kan Stream, Çoruh Basin, in north-eastern Turkey was estimated. The length-length relationships were found to be significantly linear in all cases. Moutopoulos and Stergiou (2002) determined significantly linear relationships among TL, FL and SL in some fish species in the Aegean Sea. These significantly linear relationships among the length parameters showed that certain fish species exhibited characteristic morphological features.

The *b* value was used in the length-weight relationship as the indicator of the growth type of *Salmo trutta,* to find out whether there deviation from isometric growth had occurred between the sexes and among the sampling times. When the seasonal variations were considered, the *b* value reached its maximum value of 3.04 ($r=0.99$, $N=130$) during the summer (June, July and August) and its minimum value of 2.89 ($r=0.99$, $N=133$) during winter (December, January and February). The fact that the *b* value recorded in the winter was significantly lower than 3 ($p<0.01$) indicated a negative allometric growth during this season.

Length-weight relationships may present spatial and temporal variations due to water temperature, food availability and reproductive activities (Weatherly and Gill, 1987; Wootton, 1992). Trout cannot take food at temperatures lower than 2°C or during reproductive season (Çelikkale, 1994). Hence, these fish feed insufficiently and display low *b* values during cold seasons. However, adequate feeding and gonad development increases fish weight and *b* values (Nikolsky, 1963; Arslan, 2003).

There have been some studies on the length-weight relationship of *Salmo trutta* L. in Turkish freshwaters and some other localities (Ball and Jones, 1960; Geldiay, 1968; Aras, 1974; Yanar *et al.*, 1987; Yıldırım, 1991; Yüksel, 1997; Arslan *et al.*, 2000; Arslan, 2003), and the *b* values reported in these studies are presented in Table 3. The *b* value in the length-weight relationship of fish can be used as an indicator of food intake and growth pattern, and may

Table 1. Length-length relationships of *Salmo trutta* L. N=sample size

Lengths	a	*b*±SE	Confidence Limits (95%)	r	N
TL-FL	0.3363	1.0202±0.003	1.013-1.027	0.99	509
TL-SL	0.4304	1.1178±0.004	0.110-1.125	0.99	509
FL-SL	0.1269	1.0923±0.004	1.085-1.100	0.99	509

Table 2. Length-weight relationship parameters of *Salmo trutta* L. according to the sexes and the seasons. N=sample size

Factors	N	a	*b*±SE	r	Confidence Limits (95%)	*t* value (difference of *b* from 3)
Male	239	0.0147	2.96±0.028	0.99	2.903-3.016	-0.49311
Female	250	0.0141	2.96±0.030	0.98	2.888-3.032	-0.35859
Overall	509	0.0141	2.97±0.021	0.99	2.927-3.011	1.4423
Winter	133	0.0160	2.89±0.02	0.99	2.839-2.941	-1.65841**
Spring	130	0.0124	3.01±0.03	0.99	2.951-3.075	0.140672
Summer	100	0.0112	3.04±0.05	0.98	2.9228-3.1568	0.222861
Fall	149	0.017	2.91±0.03	0.99	2.8379-2.9859	-0.80948

Significant at: * $p\leq0.05$, ** $p\leq0.01$

Table 3. b values in the length-weight relationships of *Salmo trutta* L. from different localities

Study	Locality	*b* value
Frost and Smyly, 1952	Lake District, Wales	3.000
Ball and Jones, 1960	Llyn Tegid, Wales	2.920
Geldiay, 1968	Mount Kaz streams, Turkey	1.78-3.54
Aras, 1974	Çoruh and Aras Basin, Turkey	2.97-2.78
Yanar *et al.*, 1987	Hodacur Brook, Turkey	2.996
Yıldırım, 1991	Barhal Streams, Turkey	3.000
Baltacı, 1996	Şah Lake, Turkey	3.090
Yüksel, 1997	Teke Brook, Turkey	2.590
Arslan *et al*,. 2000	Cenker Stream, Turkey	2.897
Çetinkaya*, 1999*	Catak Brook, Turkey	3.07
Tabak *et al., 2001*	Eastern Black Sea streams, Turkey	3.035
Arslan*, 2003*	Anuri and Cenker streams, Turkey	3.037-3.000

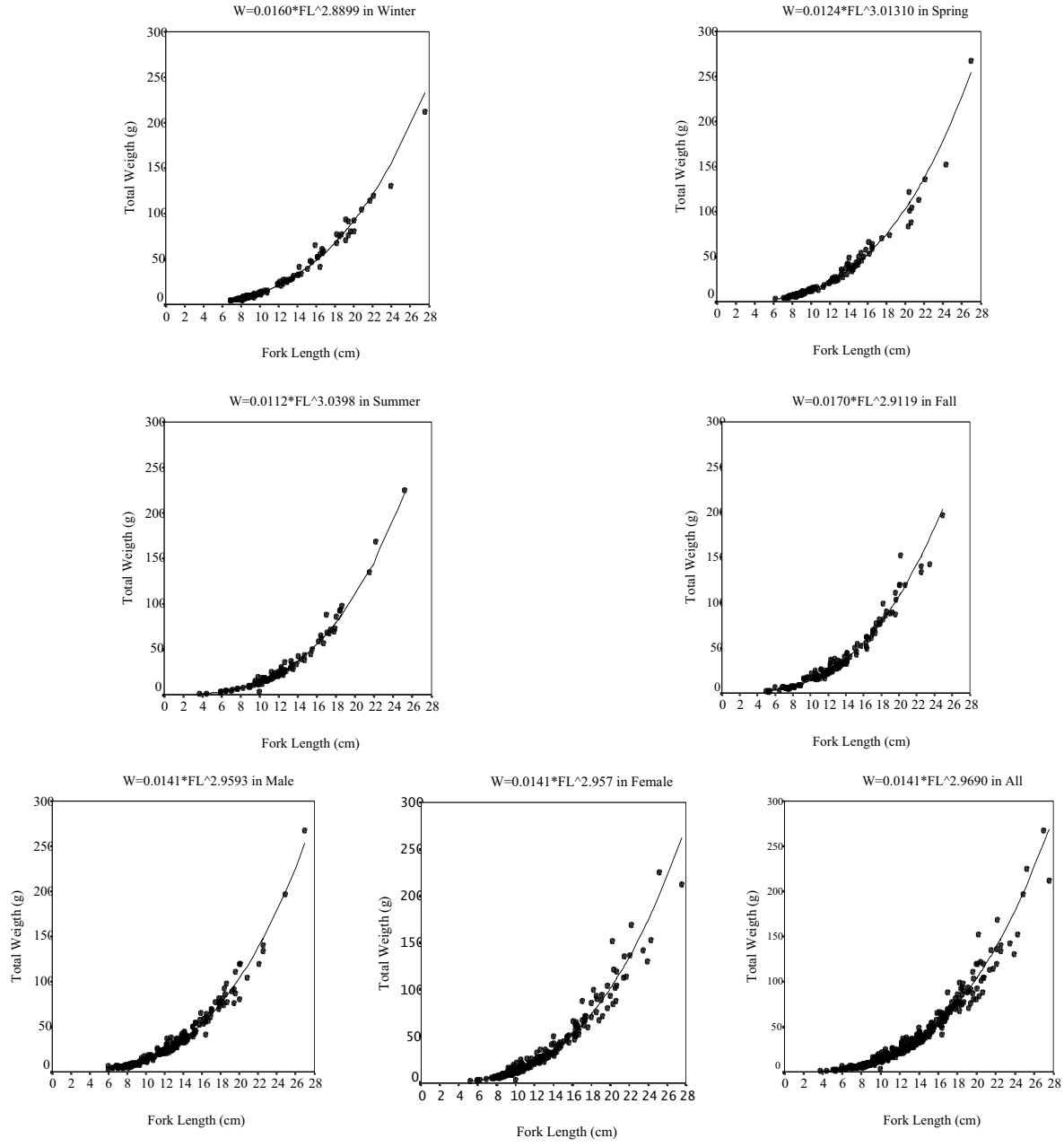

Figure 1. Length-weight relationships according to the sexes and the seasons.

differ according to such biotic and abiotic factors as water temperature, food availability and habitat type (Wootton, 1992; Avşar, 1998).

Consequently, during the winter, when biological resources were insufficient and certain abiotic factors like water temperature were inadequate, *Salmo trutta* living in the Kan Stream could not feed sufficiently and demonstrated a negative allometric growth. In contrast, environmental conditions did not change the normal isometric growth of this species during the rest of the year, and both females and males demonstrated the same growth type.

References

Aras, M.S. 1974. Çoruh ve Aras havzası alabalıkları üzerinde biyo-ekolojik araştırmalar. Ph.D. Thesis. Erzurum: Ataturk University.

Arslan, M., Aras, N.M. and Yıldırım, A. 2000. Cenker Çayı (Çoruh Havzası)'nda yaşayan *Salmo trutta labrax* (Pallas, 1811)'ın populasyon yapısı ve büyüme özellikleri. Su Ürünleri Sempozyumu 20-22 Eylül 2000 Sinop, 266-278.

Arslan, M. 2003. Çoruh Havzası Anuri ve Cenker çaylarında yaşayan alabalık, *Salmo trutta* Linneaus 1766, populasyonları üzerine araştırmalar. Ph.D. Thesis. Erzurum: Atatürk University.

Avsar, D. 1988. Balıkçılık Biyolojisi ve Populasyon Dinamiği. Baki Kitabevi, Adana, Turkey.

Ball, J.N. and Jones J.W. 1960. On the growth of the brown trout of Llyn Tegid. London Proc. Zool. Soc., 134 (1):1-41.

Baltacı, H. 1996. Şah Gölü (Aşkale) sularının fiziksel kimyasal özellikleri ve burada yaşayan alabalıkların (*Salmo trutta* L.) biyoekolojisi üzerine araştırmalar. MSc. Thesis. Erzurum: Atatürk University.

Çelikkale, M.S. 1994. İç Su Balıkları ve Yetiştiriciliği. K.T.U. Yayınları, Trabzon, Turkey. 419 pp.

Çetinkaya, O. 1999. Çatak Cayı (Dicle Nehri) Dağ Alabalıklarının (*Salmo trutta macrostigma*, Dum., 1858) Bazı Biyolojik Özelliklerinin İncelenmesi. I.U. Su Ürünleri Fak. Su Ürünleri Derg., 9: 111-122.

Erkoyuncu, İ. 1995. Balıkçılık Biyolojisi ve Populasyon Dinamiği. Ondokuz Mayıs Üniversitesi, Sinop Su ürünleri Fakültesi, Sinop, 265 pp.

Frost, W. and Smyly, W. 1952. The brown trout of Moorland fish pond. Journal Animal Ecol., 21: 62-86.

Geldiay, R. 1968. Kazdağı silsilesi derelerinde yaşayan alabalık (*Salmo trutta* L.) populasyonları hakkında araştırma. 4th Milli Türk Biyoloji Kongresi, Tebliğler, 15-21 Ağustos, İzmir, Turkey.

Gonçalves, J.M.S., Bentes, L., Lino, P.G., Ribeiro, J., Canario, A.V.M. and Erzini, K. 1997. Weight-length relationshipships for selected fish species of the small-scale demersal fisheries of the south and southwest coasts of Portugal. Fish. Res., 30: 253-256.

Karataş, M. 1997. Ataköy Baraj Gölünde (Tokat) yaşayan alabalıkların (*Salmo trutta* L.) üreme özelliklerinin incelenmesi. Tr. J. Veterinary and Animal Science, 21: 439-444.

Karataş, M. 1999. Age at sexual maturity, spawning time, sex ratio, fecundity of population of trouts (*Salmo trutta* L.) in habiting in Tifi brook (Tokat-Turkey). Symposium Development and Growth of Fishes. 5-8 July 1999. Andrews, England.

King, R.P. 1996. Length-weigth relationshipships of Nigerian freshwater fishes. Fishbyte, 19(4): 53-58.

Kuru, M. 1975. Dicle-Fırat, Kura-Aras, Van Gölü ve Karadeniz Havzası tatlı sularında yaşayan balıkların (Pisces) sistematik ve zoocoğrafik yönden incelenmeleri. Atatürk Üniversitesi, Fen Fak. Zooloji Böl., Erzurum. 180 pp.

Morey, G., Moranta, J., Massuti, E., Grau, A., Linde, M., Riera, F. and Morales-Nin, B. 2003. Weight-length relationship ships of littoral to lower slope fishes from the western Mediterranean. Fish. Res., 62: 89-96.

Moutopoulos, D.K. and Stergiou, K.I. 2002. Length-weight and length-length relationships of fish species from the Aegean Sea (Greece). J. Appl. Ichtyol., 18: 200-203.

Nikolsky, G.W. 1963. The ecology of fishes. Academic Press, London and New York. 352 pp.

Pauly, D. 1993. Fishbyte Section. Editorial. Naga. ICLARM Quart.: 16-26.

Richter, H.C., Luckstadt, C., Focken, U. and Becker, K. 2000. An improved procedure to assess fish condition on the basis of length-weight relationships. Arch. Fish. Mar. Res. 48:255-264.

Ricker, W.E. 1975. Computation and interpretation of biological statistics of fish populastions. Bull. Fish. Resh. Board Can., 191: 203-233.

Slastanenko, E. 1955. Karadeniz Havzası Balıkları. Et ve Balık Kurumu Yayınları, Ankara. 277 pp.

Tabak, İ., Aksungur, M., Zengin, M., Yılmaz, C., Aksungur, N., Alkan, A., Zengin, B. and Mısır, S. 2001. Karadeniz Alabalığı (*Salmo trutta labrax* Pallas, 1811)'nın Biyoekolojik Özelliklerinin Tespiti ve Kültüre Alınabilirliğinin Arastırılması. Su Ürünleri Merkez Arastırma Enstitüsü (Project result report, in Turkish with English abstract), Trabzon, Turkey. 203 pp.

Weatherley, A.H. and Gill, H.S. 1987. The Biology of Fish Growth. Academic Press, London. 443 pp.

Wootton, R.S. 1992. Fish Ecology. Printed in Great Britain by Thomson Litho Ltd., Scotland.

Yanar, M., Akyurt, I. and Bircan, R. 1987. *Salmo trutta* L.'nin gonada gelişimi, yumurta verimliliği, büyüme durumu ve et verim özellikleri üzerine bir araştırma. Et ve Balık Endüstrisi Dergisi, 8(48): 3-12

Yıldırım, A. 1991. Barhal Havzası alabalıklarının (*Salmo trutta labrax*, Pallas 1811) biyo- ekolojisi üzerine araştırmalar. MSc. Thesis. Erzurum: Atatürk University.

Yüksel, A. 1997. Teke deresi suyunun bazı fiziko-kimyasal parametreleri ve burada yaşayan dağ alabalıkları (*Salmo trutta macrostigma*, Dumeril 1815)'nın bazı özellikleri üzerine bir araştırma. MSc. Thesis. Erzurum: Atatürk University.